World Energy Outlook 2026

International Energy Agency

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This has been a year of unprecedented disruption in the energy world. The Strait of Hormuz crisis has created the largest threat to energy security in history, one that dwarfs the scale of the oil shocks of the 1970s.

We have already seen a multitude of short-term responses to lessen the impacts on energy systems, economies, businesses and households. Energy producers both inside and outside the Gulf stepped up to bring additional supplies to market via alternative routes and expanded production; China, the world's largest oil importer, massively reduced its purchases from international markets. Governments have intervened to try and provide some shelter for consumers, but they have nonetheless faced higher prices and, in some cases, shortfalls of supply. Diesel markets have been under extreme strain.

We are also seeing signs of longer-term responses. These are taking the form of changes in policies – and changes in perceptions of risk. Countries are building new infrastructure, such as new pipelines to avoid the Strait of Hormuz, to increase their options. The emphasis is on diversification and resilience to insulate against future shocks. Energy security and affordability are firmly at the top of the political agenda.

These priorities, particularly for fuel-importing countries, are now aligned more closely than ever with energy transition goals, since many of the energy sources and technologies that enable lower fuel imports also come with lower emissions, such as renewables, nuclear power and electrified transport and heating.

The historic 2026 energy shock demanded a historic response from the International Energy Agency (IEA). Within two weeks of the outbreak of hostilities, IEA Member countries launched their largest ever coordinated release of emergency stocks: 400 million barrels. Throughout the crisis, we have also provided essential data and analysis – tracking developments, identifying risks and assessing the evolving prospects, notably in our monthly *Oil Market Report*. In parallel, we have maintained a strong dialogue among our Member countries and the wider IEA Family – as well as with the G7 and G20, and with key oil and gas producers and exporters.

All of this has not prevented us from keeping a close eye on other energy security challenges around the world – in critical minerals and energy technology supply chains, or in electricity systems and the heightened risks coming from natural hazards, including heatwaves and wildfires. We have also maintained robust engagement on energy transitions and efforts to tackle climate change, most notably as strategic partner to the COP31 Presidencies of Türkiye and Australia.

Amid the current turmoil, it is incumbent upon the IEA to work through the long-term implications of this year's unprecedented disruption to energy markets. Much uncertainty remains over how long the Hormuz crisis will last. Volatility and unpredictability have become the norm rather than the exception in recent years – from the Covid pandemic to Russia's full-scale invasion of Ukraine and now today's crisis. And amid all the concerns about different goods being in short supply, the scarcest commodity of all, in my view, is trust.

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This is why it is more important than ever to consider the different possible energy futures that could emerge from the current period of upheaval and flux – drawing on multiple scenarios and cases, based on the latest available data and rigorous modelling and analysis. This is the role and the realm of the *World Energy Outlook (WEO)*. At a time of profound uncertainty, it reminds us that decisions taken today will have long-term consequences for the energy world of tomorrow.

Energy decision-makers need to be wary of creating new dependencies and risks, even as they seek to address old ones. But, above all, they need to look through the noise and prioritise the fuels, technologies and partners that will deliver secure, affordable and sustainable energy in the years ahead. I believe a close reading of this year's *WEO* provides essential insights to help inform these critical decisions and choices.

As such, I'm extremely grateful to the excellent team of IEA staff members who worked so effectively to produce this *WEO* in such a challenging context, under the outstanding leadership of my colleagues Laura Cozzi and Tim Gould.

Dr Fatih Birol
Executive Director
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An unprecedented shock to the system

The disruption to energy flows through the Strait of Hormuz in 2026 has been the largest energy supply shock that the world has faced and – as of November – it is not over. The energy system has shown considerable resilience in the face of cumulative losses of 2.8 billion barrels of oil and 60 billion cubic metres (bcm) of gas supply from the Gulf, but increasingly it is falling to consumers – and high prices – to absorb the impact as other buffers are run down. Exports from the Gulf have ebbed and flowed in response to changes in the security situation. Market impacts have been heightened by risks affecting transit through the Red Sea and by disruptions to Russian supply as Russia's full-scale invasion of Ukraine entered its fifth year. Supplies of diesel, the workhorse of the global economy, have come under extreme pressure, with prices hitting record levels above USD 200/barrel.

The effects of the 2026 crisis have reached all corners of the world: three-quarters of the world's population live in oil- and gas-importing countries, and more than 4 billion people live in countries that depend on the Strait for more than 30% of their oil supplies. The crisis has taken a heavy toll in the Middle East, with the energy effects including damage to infrastructure, lost export revenues and fuel shortages in some countries. Developing economies in the Asia Pacific region and in Africa have been among the worst-affected importers. Prior to the crisis, around 80% of the oil and almost 90% of the liquefied natural gas (LNG) passing through the Strait were destined for Asia.

The 2026 crisis compounds a broader sense of fragility in energy markets, amid geopolitical tensions, rising climate risks, cyberattacks and other malicious activity affecting energy infrastructure. August 2026 was the hottest month globally on record, and a strong El Niño could add to weather-related strains. High energy prices and shortfalls in fertiliser supply are creating hazards for food security. Emissions of carbon dioxide (CO_2) and air pollutants from fuel combustion remain dangerously high. Energy geopolitics are fracturing, and trade restrictions are on the rise. Trust is in short supply. Each vulnerability deepens the others.

This is also a time of profound structural change, as the world moves deeper into the Age of Electricity with a cost-competitive suite of low-emissions technologies to hand. Electricity today accounts for around 23% of final energy consumption, but it is the key source of energy for sectors accounting for over 45% of the global economy. The energy sector is starting to feel the potentially transformative impacts of artificial intelligence (AI). And, for the first time on record, a renewable source of energy, solar photovoltaics (PV), contributed not only the largest share of the increase in global power generation in 2025 but also a larger share of the growth in overall energy demand than any other source.

A range of possible energy futures

Previous energy shocks, from the 1970s onwards, all left lasting marks on the energy world: this one will too, and the longer the crisis lasts, the deeper these marks will be. It is not yet clear what a durable resolution in the Middle East might look like, and it is too soon to

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ascertain the lessons that different countries will draw. But some general conclusions are clear, chief among them being a reinforced focus on energy security and affordability as guiding principles for energy decision making. In many cases, especially among fuel importers, these concerns are closely aligned with the push for clean energy transitions.

A central question for this *Outlook* is how the 2026 crisis might alter policy preferences, risk perceptions and the mix of fuels and technologies that the world uses to meet our energy needs. There can be no single answer to this question, which is why we have multiple scenarios and cases. The **Current Policies Scenario (CPS)** is based on energy policies and regulations that are already firmly in place and offers the least scope for change to pre-existing trends. By considering specific policy measures that have formally been put forward but not yet adopted, the **Stated Policies Scenario (STEPS)** incorporates more reactions to the crisis. These scenarios assume a continued easing of constraints on Gulf exports and sufficient stability to allow for unimpeded transit through the Strait by the end of 2027.

The longer the crisis goes on and risks to oil and gas supply from the Middle East persist, the more likely it is that policy and market responses will extend beyond those in the CPS and STEPS. The **Additional Response Case (ARC)** explores this possibility: it is grounded in supply- and demand-side actions that are under consideration by governments, even if they are yet to be turned into formal policy proposals, and asks what would happen if they were implemented. The **Low Hormuz Case (LHC)** asks whether the energy world could manage without transit through the Strait.

Alongside these exploratory scenarios and cases, the **Net Zero Emissions by 2050 (NZE) Scenario** offers a normative perspective on the future, mapping out a way to bring down emissions to net zero by mid-century. It provides a global pathway towards the goal of limiting global warming to 1.5 °C, but not the only possible one.

A common starting point: rising demand for energy services

In any vision of the future, higher incomes and population mean a rising requirement for the services that energy provides, including mobility, heating, cooling and computing power. These needs rise modestly in advanced economies and more rapidly (albeit slowing over time) in China. They grow fastest in other emerging and developing economies, home to two-thirds of the world's population and to an increasing share of the world's industrial activity. India and Southeast Asia see the largest overall increase in energy needs, followed by Latin America, the Middle East and Africa. In a world of rising incomes and rising temperatures, there is a striking increase in demand for cooling. In emerging market and developing economies outside China, 85% of households are exposed to high temperatures, but less than 20% of these households currently have an air conditioner. Already today, for the first time in energy history, global cooling needs are overtaking those for heating. The underlying need for energy services is broadly similar in all our scenarios and cases, but they differ – sometimes dramatically – in the combinations of fuels and technologies that are deployed to meet these needs, illustrating the scope for policy action.

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How could the 2026 crisis reshape the energy outlook?

Responses to the crisis vary across countries, but there are some common themes:

- **Diversification** reinforced as a key policy preoccupation across multiple dimensions, including suppliers, routes, energy mixes and technology supply chains.
- A stronger preference for **domestically available resources**, which naturally vary by country.
- A push for faster electrification in the Age of Electricity.

Application of these levers has implications for demand and trade patterns for oil and natural gas, the two fuels at the centre of the crisis. In the CPS, demand for both oil and gas continues to rise. While electrification, efficiency and biofuels cut passenger car oil use to 2035, this is more than offset by a combined increase of 5 million barrels per day (mb/d) for petrochemicals, aviation and heavy trucks. Natural gas use grows strongly, backed by a wave of new LNG supply. In the STEPS, the pace of structural change is faster. Oil demand levels off at around 103 mb/d by 2030 before entering a slow decline; natural gas demand rises to the mid-2030s before plateauing. In the ARC, in which security risks and uncertainties are assumed to persist for longer, oil use starts to fall earlier and by 2035 is more than 4 mb/d lower than in the STEPS. Global gas demand grows but at a slower pace than in the STEPS, and demand for LNG is hit. In the NZE Scenario, meeting stringent emissions goals requires much more rapid substitution of oil and gas, putting their use into earlier and faster decline.

Diversification: The first golden rule of energy security

Confidence in the Strait of Hormuz has been shattered and additional bypass projects are moving ahead, but it will not be easy or quick to manage without oil shipments through this strategic waterway. In the case of oil, around 7 mb/d of new pipeline projects are under construction or under consideration that enhance the ability of Gulf producers to reach international markets without going through the Strait. Building them would require an estimated USD 40 billion, adding around USD 2 to the cost of a barrel of oil exported from the Middle East. If all these projects are completed, non-Gulf producers step up output, and importers bring down demand as in the ARC, then our Low Hormuz Case reduces the need for transit through the Strait to 2 mb/d by 2035. But this finding comes with two important qualifications. As already seen in 2026, if the Middle East is unstable, then alternative routes for Gulf exports are likely to be vulnerable too. And while it is possible to diversify away from the Strait of Hormuz over time, the same does not apply to the Middle East as a whole. Even in this extreme case, the Middle East remains the largest exporter of oil to international markets, underlining that supplies from this region are still vital for oil markets and security.

The priority attached to diversification and additional layers of fuel security could have wide-ranging implications, but building up buffers and contingencies comes with a cost. The push to diversify supply creates opportunities for non-Gulf producers, notably in the Americas, where the United States, Canada, Brazil, Guyana, Argentina and Venezuela are all

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looking to increase output. In all scenarios, we assume a focus on replenishing oil stocks and building them up in parts of Asia that have been strongly affected by shortfalls; drawdowns of inventories, including the largest ever co-ordinated release of oil stocks by the IEA, provided a crucial safety net in 2026. Some countries are looking at options in the refining sector to bolster the reliability of oil product supply, often through upgrades to existing assets. Decisions to build new refining capacity require durable demand prospects and competitive conditions for operation; security-based rationales can quickly turn into expensive and open-ended subsidy commitments.

The importance of diversification extends well beyond Hormuz and oil security. There are other chokepoints: in the STEPS and CPS, flows through the Strait of Malacca in Southeast Asia rise to 23-25 mb/d and 200-250 bcm of LNG in 2035 as import demand increases across Asia. There are other fuels to consider besides oil. Gulf LNG exports have no feasible bypass routes, although the importance of the Strait of Hormuz for global gas security is somewhat mitigated by the rapid rise in alternative LNG supplies from other countries, notably the United States. There are also excessive dependencies elsewhere in the energy system. Examples include producer economies that are highly dependent on revenues from oil and gas exports, or the concentrations seen in clean technology manufacturing and in critical mineral supply chains. China is the dominant refiner for 19 out of 20 energy-related strategic minerals, and more than half of these are subject to export controls.

A premium on domestically available resources

Renewables are already the technologies of choice in the power sector in many parts of the world and are set to get a further boost from the tilt towards homegrown energy. The 2025 increase in solar PV generation, 600 terawatt-hours (TWh), was the third-largest ever achieved by any energy source in a single year. Trade data for 2026 show a rapid increase in imports of solar PV modules and batteries to countries in Africa and Asia strongly affected by the crisis. There is ample supply available. Current global manufacturing capacity for both technologies is roughly twice the volumes deployed in 2025, contributing to intense competition and falling prices. Renewables grow strongly in all scenarios: from a share in electricity generation of 33% today, by 2035, renewables account for 45-50% in the CPS and STEPS, and an even higher share in the ARC. Solar takes the lead and others follow, including onshore and offshore wind, and sources of firm or flexible power such as hydropower, bioenergy and geothermal.

In an echo of the 1970s, the 2026 crisis is set to reinforce the comeback of nuclear power. As of mid-year, nearly 90 gigawatts of new nuclear capacity was under construction, the highest level for more than 35 years, and over 50 countries now have plans or targets for nuclear power, including new technologies such as small modular reactors. Nuclear power generation has been revised upwards compared with the *World Energy Outlook 2025* (*WEO-2025*), with much of the upside in China and the United States. Our projections now open up the prospect of nuclear power growing more rapidly than electricity demand, pointing to an increased share in the electricity mix from its current 9%.

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Energy efficiency is sometimes overlooked as a domestic resource, but the "first fuel" is widely available and its benefits extend well beyond energy security. The potential for improvements is spread across the energy system. In the residential sector, the efficiency gains made in lighting, televisions, refrigeration and other white goods over the past decade, at 600 TWh, are greater than the world's annual consumption of electricity for data centres. Aligning minimum energy performance standards in all countries with the most stringent standards in force today would unlock an additional 800 TWh of savings by 2035.

Some fuel-importing countries are looking to boost their domestic production of oil and gas, but in most cases, the upside is minor. Average upstream investment in fuel importers in the ARC is around 10% (or USD 10 billion) higher than in the STEPS, but the resource base in most importing countries is either small or mature. Incremental production takes time to develop and typically requires easing fiscal terms to make it economically viable. Biofuels could benefit from a stronger focus on energy security, especially in Southeast Asia, but this will require greater efforts to avoid competition with food production and align with sustainability criteria. There is also potential in some countries, such as India and Morocco, to step up green ammonia production and diversify supplies of fertilisers and feedstocks.

The structural forces pushing coal use into decline are strong, but coal resources in many oil- and gas-importing countries are large, especially in Asia, and energy security concerns could keep some coal assets in the mix for longer. Coal demand has received a short-term boost from the crisis, but by 2030, it is in decline in all our scenarios. In the STEPS, global coal-fired generation falls by around 15% to 2035, and industrial use by 5%. China is central to this story. It accounts for more than half of global coal demand, but rapid growth in renewables and nuclear shifts China's coal-fired fleet from providing bulk electricity towards meeting peak demand and providing flexibility. The decline in global coal demand is slightly less steep in the ARC, indicating the potential for coal to retain a firmer foothold in a world that puts a high priority on energy security and domestically available resources.

Further into the Age of Electricity

The world was already moving at pace into the Age of Electricity prior to 2026; the crisis has reinforced the strategic case for electrification. Since 2019, electricity demand has grown by 3.3% per year, faster than growth in global gross domestic product (2.9% per year) and twice as fast as total energy demand growth (1.5% per year). Many countries have turned to electrification as a strategic response to events in 2026: twenty-five have announced new electrification-related policies since February. Consumers are also taking matters into their own hands, with sales of electric cars up sharply year-on-year in countries across Europe and Southeast Asia, in Australia, Brazil, India, Korea and beyond. Countries that electrified early have seen a payoff during the crisis: China's rapidly growing electric vehicle (EV) fleet is avoiding around 1.5 mb/d of oil consumption.

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Electricity use is being driven higher by multiple factors: in industry by electric motors; appliances by rising incomes; for air conditioners also by rising temperatures; in EV and heat pump sales by lower costs and higher fuel prices; and data centres by the AI boom. Demand grows by more than 10 000 TWh over the next decade, by which time the global electrification rate (the share of electricity in final energy consumption) is closing in on 30% in the CPS and STEPS, up from 23% in 2025. In the ARC, the global rate is pulled slightly higher by faster electrification in oil- and gas-importing countries. Based on prevailing prices in 2025, our analysis finds that there is cost-competitive potential to electrify about half of road transport fossil fuel demand, around half of global fossil fuel-based space heating demand, and nearly 40% of global fuel-based demand for low- and medium-temperature heat in industry.

Successful electrification means keeping electricity available and affordable, putting the emphasis on effective use and expansion of grids, and greater operational flexibility in power systems. Over the next ten years, at least 25 million kilometres of new power lines are needed to keep up with rising demand and integrate new sources of supply, and 15 million kilometres of existing lines need replacement or upgrades. All these investments require copper, transformers, cables and other key pieces of electrical equipment for which supplies are currently tight. A focus on affordable electricity requires policies that incentivise efficient grid operation; facilitate investment in the infrastructure, locations and technologies that bring most value to the system, including battery storage and demand response. A focus on affordability also means subjecting all aspects of electricity bills – including the tax treatment of electricity versus other fuels – to scrutiny. AI could help to optimise the electricity system and bring down costs, but for the moment, surging demand from data centres is amplifying strains in some markets and supply chains.

Policy makers need to be watchful for a range of new security risks as the energy system electrifies. Electrification can reduce exposure to fossil fuel supply risks and bring down emissions, but without parallel efforts to diversify critical mineral and technology supply chains and expand investment in low-emissions power generation, flexibility and grids, it may shift rather than reduce vulnerabilities. Cyberattacks on energy utilities worldwide have risen steadily as energy systems have become more digitised, with more than 2 000 attacks per week in 2025. In addition, since 2022, there have been around 3 000 major energy outages reported globally linked to natural hazards, affecting more than 850 million households and businesses. Electricity systems are particularly exposed. On the demand side, our scenarios consider the likely effect of long-term increases in average temperatures on cooling demand, but this Outlook also explores a heatwave case in which stronger, more frequent and longer heatwaves raise levels of both air conditioner ownership and use. Cooling demand already increases by 1 700 TWh by 2035 in the STEPS. In the heatwave case, the increase is 40% higher, an extra 700 TWh, with particularly strong implications for peak demand.

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Could the crisis accelerate energy transitions?

There is an increasing alignment of energy security and energy transition objectives in many countries, underpinned by strong economics for key low-emissions technologies, but security concerns alone will not drive an adequate response to climate change. The ARC accelerates aspects of energy transitions, notably in fuel-importing regions, but the overall reduction in emissions is only slightly faster than in the STEPS, and warming levels in 2100 are 2.4 °C, compared with 2.5 °C in the STEPS. The effect of accelerated deployment of low-emissions technologies in the ARC is offset in part by higher coal use. In the CPS, global CO_2 emissions barely change from today's level, leading to warming of around 2.9 °C in 2100. If countries want to accelerate energy transitions, emissions reductions need to be a higher priority; security concerns only get them part of the way. However, in many cases, the policy focus on transitions seems to have waned. For example, the level of ambition expressed in the new round of Nationally Determined Contributions under the Paris Agreement varies but does not point in aggregate to a significant acceleration in energy sector emissions mitigation, compared with previous submissions.

As countries gear up to start the second Global Stocktake in late 2026, the NZE Scenario provides a valuable benchmark for tracking progress and policy ambitions, while safeguarding energy security and affordability. Options to reduce emissions substantially are well understood and, in many cases, cost effective. In the NZE Scenario, emissions reductions are built on four pillars. First, a massive expansion in low-emissions power generation, with the share of renewables and nuclear rising to almost 90% of generation in 2035, up from 42% today. Second, efficiency improvements and electrification of end-uses, including a global electrification rate that reaches 35% by 2035. Third, a growing role for low-emissions fuels, and rapid reductions in methane emissions from fossil fuel operations to mitigate near-term warming. Fourth, CO_2 capture and storage, including CO_2 removal technologies that are now essential to limit the overshoot of temperature goals. The NZE Scenario also transforms the energy security landscape, dramatically reducing fossil fuel demand and trade, while underscoring emerging security issues in the electricity sector and in supply chains for clean technologies and critical minerals.

Access to modern energy remains a huge development challenge

The 2026 crisis is setting back efforts to expand access to electricity and clean cooking fuels to the hundreds of millions of people that remain without. Latest IEA tracking points to an acceleration in access to electricity and clean cooking in 2025, but around 720 million people still live without electricity, and nearly 2 billion rely on polluting cooking methods. Sub-Saharan Africa is home to 90% and 50% of these populations, respectively. Past shocks show how quickly momentum can be eroded: in 2022, the price spikes that followed Russia's full-scale invasion of Ukraine meant that the number of people without electricity increased worldwide for the first time in decades, and progress on clean cooking slowed. The deficit in 2026 of liquefied petroleum gas (LPG) has been a major risk factor: around 75% of the people gaining access to clean cooking worldwide over the past decade have done so through LPG,

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and the Middle East was a large exporter. Reduced supply and higher LPG prices risk slowing adoption among first-time users and pushing households that recently switched to LPG to cut back or to use it alongside traditional fuels. IEA analysis highlights country-specific ways to regain momentum by replicating the best historical rates of progress in comparable contexts, which leads to universal access to electricity worldwide in 2035 and to clean cooking in 2040.

Could oil and gas prices tumble once the crisis is over?

A resolution to the 2026 crisis could usher in a buyers' market for oil and natural gas, with significant downward pressures on prices. The prospects and timing of any resolution are highly uncertain but, if constraints on flows through the Strait of Hormuz are decisively eased, market balances could switch. Demand for oil and gas would get near-term support from the rebound from crisis conditions as well as a push to restock and build up inventories. But – as illustrated in the ARC – demand could also be undermined by new structural shifts. Meanwhile, supply could be buoyed by a range of countries that are looking to raise output. The United Arab Emirates, now outside the Organization of the Petroleum Exporting Countries, has strong expansion plans. Venezuela's production prospects have been revised up to 1.5 mb/d in the STEPS in 2035 (0.9 mb/d more than in the *WEO-2025* STEPS) on the back of USD 70 billion in investment over the next ten years as operators refurbish existing facilities and develop new fields. A buyers' market would bring pressure not only on prices but also on producers to offer better or more flexible terms, including lower emissions intensities, to compete for consumers.

A second gas supply crisis within five years creates major risks for LNG balances, if it discourages commitments to import infrastructure at a moment when exports surge. A huge wave of new LNG export projects, led by the United States, is on the horizon. If all these projects come through as planned, this would expand LNG supply by more than 50%, an extraordinary rise. Our scenarios illustrate the wide range of possible outcomes. In the CPS, all the new LNG finds a home, mainly in Asia, and prices need to rise again in the 2030s to bring new projects forward. The overhang of supply in the STEPS persists for longer before clearing. The ARC, however, illustrates a profoundly different dynamic, in which lingering uncertainty over the prospects for Middle East supply makes price-sensitive importers in Asia more wary of gas. These importers turn instead to domestically available alternatives and choose to invest less in import terminals, pipelines and other gas infrastructure. This would set the stage, if Middle East LNG then becomes available at scale and exporters follow through with all their expansion plans, for a huge and lasting imbalance in gas markets.

If a period of lower fuel prices comes, it could set up a struggle between the policy lessons from the crisis – which encourage alternatives to oil and gas – and economic drivers that could boost their consumption. Fuel price volatility has been a major strain in recent years, especially on lower-income importing countries and on lower-income consumers across the board. Even though demand is down, spending on imported oil and gas worldwide in 2026 is set to rise to USD 1.6 trillion, 25% higher than in 2025. A period of lower prices would offer

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welcome relief for consumers. But energy history tells us that the markets for energy commodities move in cycles and that high prices are likely to return – especially in a world of heightened geopolitical tensions. Countries cannot fully insulate themselves from international markets, nor would it be desirable to do so. Energy trade brings huge benefits, allowing countries to access cheaper resources that they lack at home. But, over time, electrification – underpinned increasingly by domestically available renewables – promises to shift the energy system towards a fundamentally different model, with a more stable and predictable retail electricity price becoming the main component of consumer energy bills.

Investment needs are rising, but so is uncertainty

Moving the energy system onto different foundations requires a major increase in energy investment, which is challenging in a world of geopolitical uncertainties and higher interest rates. Investment rises in all our scenarios, but structural changes in energy are particularly capital-intensive, and this applies to the construction of a more electrified, renewables-rich system. Some important shifts in capital flows are already underway. Among energy importers, annual spending on low-emissions power, efficiency, electrification, grids and storage has risen by almost USD 500 billion since the last energy crisis of 2022, and this trend is given extra impetus by today's crisis, notably in South and Southeast Asia. But geopolitical tensions cast a long shadow over investment decisions, both within the Middle East and outside. And a period of higher borrowing costs disadvantages capital-intensive investment choices, especially in emerging and developing economies that already face a high cost of capital. Investment requirements in oil and gas vary according to the outlook for demand but are underpinned in large part by the need to offset declines in output at existing fields. Of the USD 540 billion invested in upstream oil and gas each year over the past five years, nearly 90% has been to offset production declines.

Building a more resilient energy future

The immediate pressures of the current crisis must not obscure the choices that will shape energy security, sustainability and prosperity for decades to come. Multiple near-term uncertainties are drawing the attention of decision makers towards the present and the continued risk of price spikes and disruptions, alongside the urgent task of protecting consumers. But decisions and measures taken today will have lasting implications for the future. A central lesson of this crisis is the need to address underlying vulnerabilities before they become costly disruptions, through sustained investment, diversification, efficiency and innovation. Countries will pursue different pathways, reflecting their resources, circumstances and priorities, but all have a stake in an energy system that is more secure, affordable and sustainable, and in effective co-operation to achieve it. This *Outlook* provides a basis for these decisions, looking beyond the immediate turmoil to examine where today's choices lead, and where the opportunities lie to build a more resilient energy future.

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PART A
CONTEXT AND KEY FINDINGS

Part A of the *World Energy Outlook* provides an overview of some of the central findings from this year's analysis, frames them within the rapidly changing global energy context, and describes the scenarios and cases that underpin them.

Chapter 1 explores ten questions on the future of energy and how they play out across scenarios. These range from the implications of the 2026 energy crisis and the trade-offs involved in boosting energy security to the outlook for emissions, the prospects for electrification and the implications for the energy sector of the rapid growth in AI investment.

Chapter 2 sets out the context for this year's *Outlook*. It covers recent trends in the global energy system and includes a close look at the 2026 energy crisis, placing it in historical perspective and examining its impacts to date on energy markets, prices and policy priorities. It also introduces the scenarios and cases used in the *Outlook* and the key assumptions that underpin them.



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Overview and key findings

Ten questions on the future of energy

SUMMARY

- The world has been through several major oil supply shocks since 1970. The current crisis is by far the largest. The effects were cushioned by well-stocked inventories, the IEA co-ordinated release of emergency stocks, alternative routes that allowed some Gulf oil exports to bypass the Strait of Hormuz, increased exports from the Atlantic basin, and a large reduction in Chinese crude imports. But increasingly the burden of adjustment is falling on consumers via demand destruction and high prices.
- Demand for energy services, such as mobility, cooling, heating and industrial production, continues to grow in the coming decades as the global population rises by 650 million people and the global economy is one-third larger by 2035. The energy needed for these services grows gradually in advanced economies, at a decelerating pace in the People's Republic of China (hereafter China), and rapidly in other emerging market and developing economies, led by India and Southeast Asia.
- The 2026 energy crisis could have important impacts on risk perceptions and technology choices. It could boost deployment of a range of low-emissions technologies and speed up the electrification of end-uses, especially in oil- and gas-importing regions seeking to limit import dependence. However, energy security considerations in the Additional Response Case (ARC) also provide some support for coal use, particularly in regions with abundant domestic resources.
- Vulnerabilities in traditional fossil fuel supply systems have again been highlighted in 2026. In considering responses, governments need to grapple with a new set of risks affecting electricity security and critical mineral value chains, and threats to energy infrastructure from natural hazards and cyber-attacks.
- Energy-related CO_2 emissions remain around today's levels in the Current Policies Scenario (CPS) but start to decline in other scenarios. Emissions fall further in the ARC than in the Stated Policies Scenario (STEPS) but remain a long way short of the reductions required to meet climate goals. New Nationally Determined Contributions do not point to a significant acceleration in energy-sector greenhouse gas mitigation compared with the previous submission cycle.
- Momentum behind efforts to expand access to modern energy services could be dented by price spikes and supply disruptions. Around 720 million people worldwide still live without electricity, and nearly 2 billion rely on polluting cooking methods.
- The boom in artificial intelligence-related investment is pushing up electricity consumption by data centres, which doubles to reach 1 000 terawatt-hours by 2030 in the STEPS. The boom is also revealing several constraints related to grids, supply chains and, in some cases, public acceptance.

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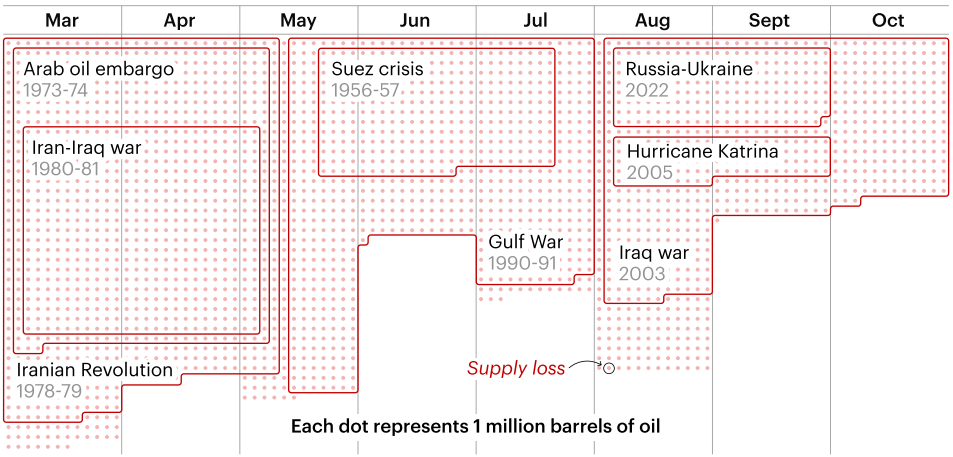
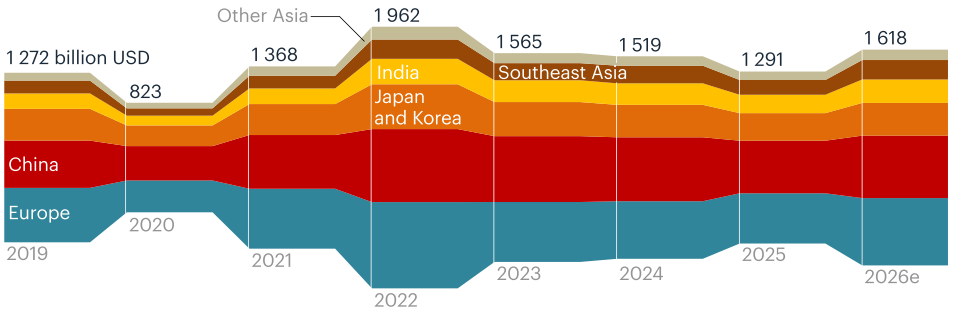
An unprecedented shock to the system

As of the end of October 2026, the overall loss in oil supply from the Middle East because of the Hormuz disruption reached 2.8 billion barrels, much larger than any previous shock.



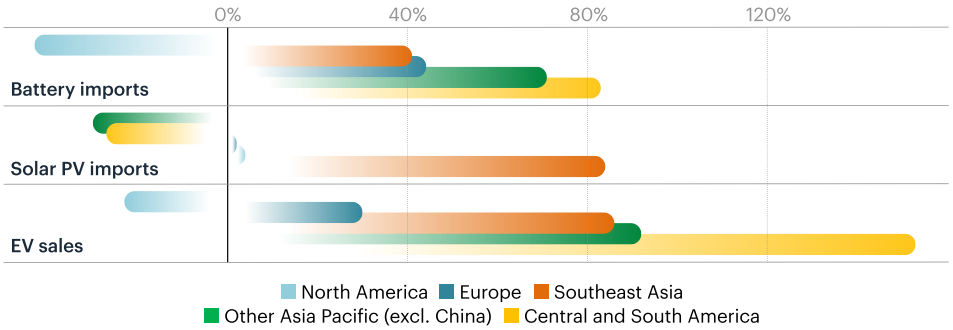
Renewed pressure on oil and gas import bills

The second major energy crisis in five years has hit consumers hard, especially in fuel-importing countries, pushing affordability even higher up the policy agenda.



Consumers are responding

The available data for 2026 suggest that the oil and gas supply shock is accelerating solar PV, battery and EV adoption in many countries, compared with the same period in 2025.



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Introduction

In another tumultuous year for the energy sector, a central task for this year's *World Energy Outlook* is to assess the longer-term implications of the 2026 energy crisis for global energy trends. Will the crisis prompt a change of direction, reshaping the fuel and technology choices made by consumers and policy makers around the world? Or will trajectories from before the conflict in the Middle East reassert themselves when the energy system reaches calmer waters? And what will this mean for energy-related emissions, or for the prospects of providing modern energy to all?

There can be no definitive answers to these questions, which is why this *Outlook* – like its predecessors – contains multiple scenarios and cases, none of which is a forecast of what will happen. The Current Policies Scenario (CPS) and Stated Policies Scenario (STEPS) are based on different readings of prevailing policy settings and how fast the energy system can evolve. However, given that the crisis is not yet over and that the CPS and STEPS do not capture all the ways that governments may respond over time, we have included cases that explore the potential for additional actions. The Additional Response Case (ARC) is grounded in an assessment of supplementary actions and policy directions that are under consideration by governments and examines what their full implementation could mean. The Low Hormuz Case (LHC) asks whether and over what time horizon the world could manage without energy flows through the Strait of Hormuz. A different perspective on the future comes with the Net Zero Emissions by 2050 (NZE) Scenario, which assesses what it would take for the energy sector to reduce emissions to net zero by mid-century. Unlike the other scenarios and cases in this *Outlook*, the NZE Scenario works back from a specific outcome and maps out a way to achieve it.

This chapter provides an overview of the key findings from this year's analysis. It is structured around the following ten questions on the future of energy:

- How much energy will the world need?
- Will the 2026 energy crisis accelerate energy transitions?
- What does the 2026 crisis tell us about our ability to cope with oil supply shocks?
- How fast could electrification go?
- Are we on the verge of a peak in emissions and what will it take to bring them down?
- What does energy security look like in tomorrow's energy system?
- Are we heading for a world of energy abundance or energy scarcity, and what will this mean for prices?
- How can the world maintain momentum on access to electricity and clean cooking?
- What's next for the world's oil and gas producers?
- What does the wave of artificial intelligence (AI) investment mean for the energy sector?

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1.1 How much energy will the world need?

The world remains thirsty for energy. Since the IEA was established in 1974, energy demand has risen by about 50% in advanced economies, while increasing tenfold in China and roughly tripling in other emerging market and developing economies, with the differences between regions reflecting different starting points and needs. Overall global energy demand has almost tripled, and economic and population growth means that demand for energy services, like mobility, cooling, heating and computing power, will continue to increase. How much energy will be required to meet this growing demand for energy services will depend on the precise mix of services that are needed, and on the policies and technologies that shape how this demand is met.

From useful energy to the energy that we actually use

Across regions, demand for energy services continues to grow in the coming decades as the global population rises by 650 million people and the global economy is a third larger by 2035. These services are delivered in different ways that cannot be compared directly. Useful energy provides a standardised framework to quantify these services in an energy-based measure.

"Useful energy" is the energy that drives the output of the desired end-use – for example, the light produced by a lightbulb, or the heat produced by a heater. It differs from both primary energy (coal or crude oil, for example), which is the resource that enters the energy system, and final consumption, which is the amount of energy actually consumed by end-users (the energy used for cooking, lighting, heating and so on). These differences reflect the large conversion losses that occur as primary energy is transformed into fuels which are then consumed by end-use equipment such as cars, industrial motors or boilers. About two and a half times more primary energy is used each year than useful energy, and around 330 exajoules (EJ) of energy are wasted each year as primary energy is converted into useful energy (excluding traditional use of biomass and non-energy use). Total primary energy reached 670 EJ in 2025, but total final consumption was much lower at around 470 EJ, and useful energy was lower still at 275 EJ (Figure 1.1).

The amount of energy that is required to deliver useful energy varies widely by scenario, depending on the efficiency of the fuels and equipment that are used. Two structural changes are particularly important in this respect. The first is that the electrification of end-use sectors represents a huge efficiency gain because electricity is inherently a more efficient way of delivering energy services than fuel combustion. The second is that renewable technologies like wind and solar photovoltaics (PV) likewise lead to major efficiency gains because they avoid the losses of waste heat associated with fuel combustion for electricity generation.

For these reasons, scenarios with faster electrification and more rapid growth in renewable energy see slower growth in total energy demand. By 2035, useful energy demand grows at the same rate in the CPS and STEPS, but total final consumption grows by 10% in the STEPS

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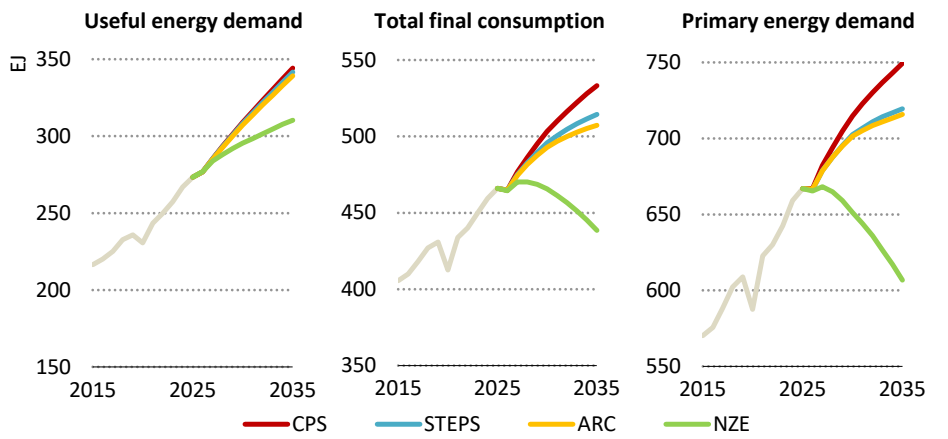
compared with 15% in the CPS because electrification proceeds more rapidly in the STEPS. The share of renewables in the generation mix also grows more rapidly in the STEPS, and the overall result is that primary energy demand grows by 8% in the STEPS by 2035, compared with 12% in the CPS. In the NZE Scenario, faster electrification and take-up of renewables accelerate the decoupling between useful energy demand and total final consumption, reducing losses along the transformation steps by 25% to 250 EJ by 2035.

Figure 1.1 ▷ Useful energy demand, total final consumption and primary energy demand by scenario, 2015-2035



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Demand for energy services is met more efficiently over the next decade, decoupling growing energy service needs from energy product consumption

Note: EJ = exajoule; STEPS = Stated Policies Scenario; CPS = Current Policies Scenario; NZE = Net Zero Emissions by 2050 Scenario; ARC = Additional Response Case.

Useful energy continues to grow but its drivers differ

Globally, useful energy demand grows by 25% in the next decade and by 60% by 2050, although there are some variations by scenario (Box 1.1). Cooling contributes more than 40% of the growth by 2035 in all scenarios, driven by demand not only in countries in the tropics but also in countries where cooling emerges as a new source of demand growth as a result of heatwaves and warming summers, notably in Europe. By mid-century, there is more cooled floorspace than heated floorspace across the world.

In advanced economies, useful energy grows at a stable pace (Figure 1.3). Having declined since 2000, industry sees a small rebound in useful energy demand by 2050 as production grows. Useful energy for heating, the single largest source of demand, decreases slowly in the outlook as improved insulation and higher average temperatures offset the effect of rising incomes. The rise in useful energy demand in transport is relatively modest as most countries already have high levels of car ownership.

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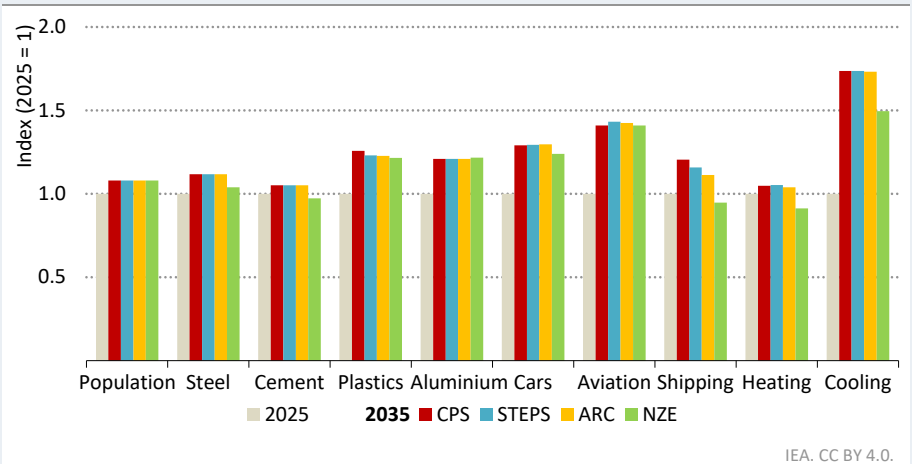
Box 1.1 ▷ Explaining variations in energy service demand across scenarios

The level of energy service demand varies by scenario, with the different policies in each scenario leading to contrasting outcomes across sectors (Figure 1.2). For example, higher recycling rates in the STEPS reduce plastics production growth compared with the CPS, and the larger number of well-insulated buildings in the NZE Scenario lowers heating and cooling needs compared with both the CPS and STEPS, for the same level of comfort.

Figure 1.2 ▷ Selected demand drivers by scenario, 2025 and 2035



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Most demand drivers rise over the next decade, with cooling needs increasing the most; the extent of the rises differs by scenario

Note: Selected demand drivers are industrial material production for crude steel, cement, plastics and aluminium; activity for cars, aviation and international shipping; and useful energy demand for heating and cooling.

Different levels of demand for fossil fuels lead to different outcomes. Fossil fuel trade is a primary driver of the shipping sector, and higher fossil fuel demand in the CPS than in other scenarios increases shipping needs. Higher demand for fossil fuels also means higher prices for those fuels; conversely, scenarios with lower fossil fuel demand produce lower equilibrium international prices for those fuels, which tends to push up service demand in price-sensitive sectors that largely rely on fossil fuels.

Infrastructure development also influences energy service demand: in the NZE Scenario, transport infrastructure expands and supports modal shifts that have an impact across all modes of transport – for example, a shift from aviation to high-speed rail, and a shift from cars to public transport in cities. So do different global temperature outlooks: for example, the CPS entails a higher long-term rise in average global temperature compared with the STEPS, which would result, all else equal, in higher cooling needs and lower heating requirements.

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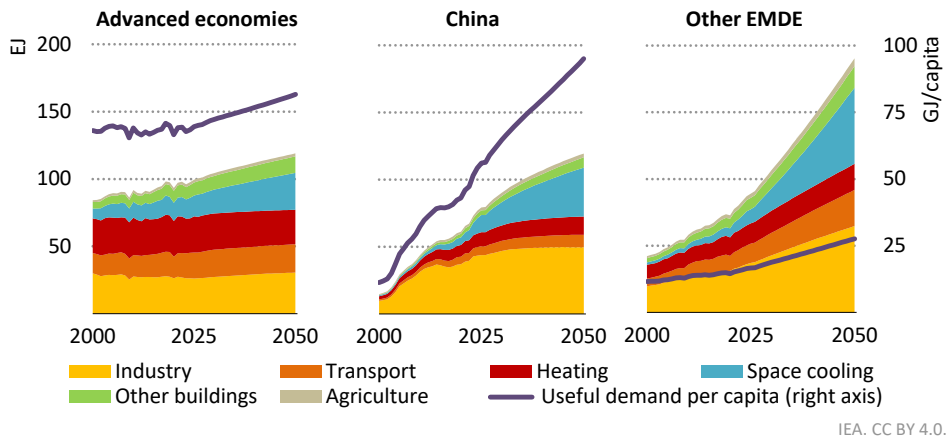
In China, useful energy demand growth levels off in the outlook after a massive surge since 2000. Industrial production growth was responsible for 50% of this surge – almost three times as much as heating and transport combined. In 2000, China accounted for 27% of global industrial production (aluminium, crude steel, cement, primary chemicals), and today this figure stands at 45%. Most heating demand was concentrated north of the Qinling-Huaihe line in 2000, but southern China has since seen a sharp rise in sales of heat pumps and natural gas boilers. In the outlook, industrial useful energy stabilises and most of the growth is driven by household demand for heating, cooling and appliances. In the STEPS, cooling needs alone contribute 60% of the growth in useful energy in China by 2050.

Figure 1.3 ▷ Useful energy demand by sector and per capita by region in the STEPS, 2000-2050



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Space cooling drives half of the growth in useful energy by 2050, double its contribution since 2000, with useful energy demand increasing fastest in EMDE outside China

Notes: GJ = gigajoule; EMDE = emerging market and developing economies. Useful energy excludes the traditional use of solid biomass and non-energy use. Other buildings includes appliances, lighting, cooking, water desalination and data centres.

In emerging market and developing economies outside China, useful energy demand has grown by 4% a year since 2020 and is set to continue to rise rapidly to 2050. Demand for air conditioning skyrockets across the board: 85% of households in emerging market and developing economies outside China are exposed to high temperatures for at least parts of the year, but less than 20% of households have an air conditioner (AC) today. This share rises to 32% by 2035 and 45% by 2050 in all scenarios. By 2050, the level of car ownership approaches one-quarter of the average of advanced economies today, and useful energy demand from transport doubles.

The centre of demand growth shifts

From today to 2035 in the STEPS, useful energy demand grows fastest in India (6% per year) and Southeast Asia (5%), followed by Africa (4%), Central and South America and

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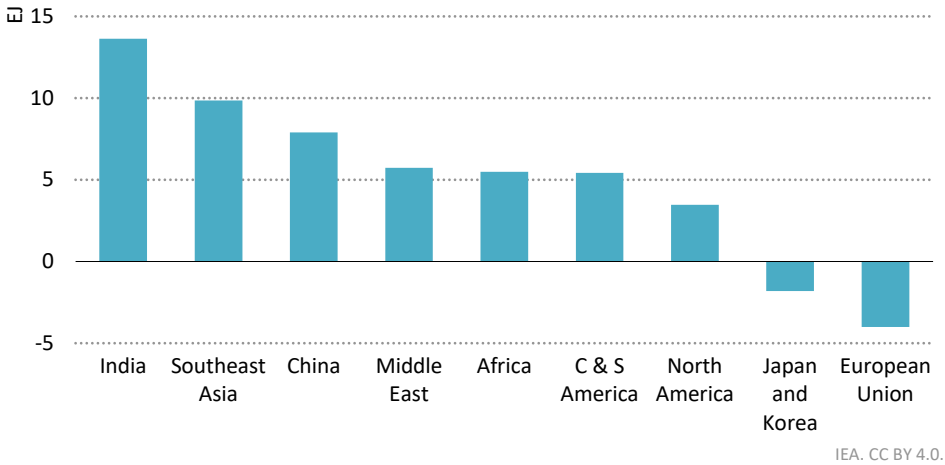
the Middle East (3% each). Emerging market and developing economies outside China are home to 65% of the world's population, and by 2050, they account for almost 45% of global useful energy demand as industrial production doubles, overtaking China's in aggregate soon after 2030. India and Southeast Asia are the new global centres of service demand growth, and they account for more than half of useful energy growth in these economies by 2050.

Figure 1.4 ▷ Primary energy demand growth by region in the STEPS, 2025-2035



India and Southeast Asia lead primary energy demand growth to 2035

Note: C & S America = Central and South America.

The geographic concentration of growth in emerging market and developing economies outside China is even more striking for primary energy demand than for useful energy demand: India and Southeast Asia account for 45% of primary energy demand growth to 2035 in the STEPS, taking over a leading role held first by advanced economies pre-2000 and then by China over the last 25 years (Figure 1.4).

1.2 Will the 2026 energy crisis accelerate energy transitions?

Energy crises can have consequences that extend beyond short-term supply disruptions and price increases, with reactions to crises potentially reshaping policy preferences, perceptions of risk and consumer choices long into the future. The oil shocks of the 1970s illustrate this dynamic: by exposing the vulnerabilities of oil dependence, they reinforced incentives to diversify energy sources, improve efficiency and develop alternatives to oil such as nuclear power (Figure 1.5). The 2022 energy crisis also had longer-term effects: it accelerated the European Union's energy transition by speeding up the rise of wind and solar and structurally diversifying gas supplies. The 2026 energy crisis could also have important impacts on risk

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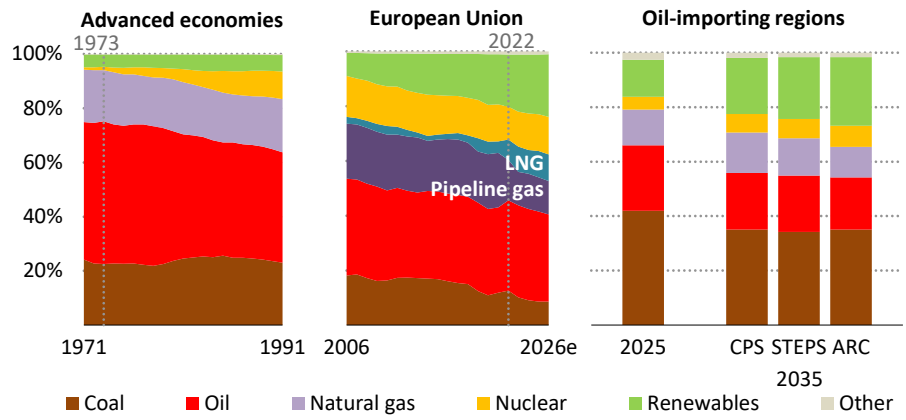
perceptions and technology choices, and this is a key question examined in the scenarios and cases in this *World Energy Outlook*.

Figure 1.5 ▷ Total primary energy supply by fuel following major crises for selected regions, 1971-1991 and 2006-2026e; oil-importing regions by scenario, 2025-2035



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Previous energy crises have led to measures to reduce oil demand and diversify gas supplies; the impact of the current crisis will depend on the policy response

Notes: 2026e = estimated values for 2026; LNG = liquefied natural gas. Other includes traditional use of biomass and non-renewable waste. Natural gas includes both pipeline gas and LNG.

Some fuel-importing regions are accelerating clean technology deployment

The rise in oil product prices during the 2026 energy crisis has improved the cost-competitiveness of electric vehicles (EVs) at a time when manufacturers are introducing more affordable electric car models in some regions. Around 28% of all car sales are set to be electric in 2026, and electric cars are expected to account for 7% of the global car stock by the end of the year (Box 1.3). Electrification is also advancing in other segments of the market for vehicles: electric medium freight and heavy freight truck sales rose nearly 75% in the first half of 2026, with China continuing to play a leading role in market growth. At the same time, sales are increasing across several European markets, with growth also in India, Brazil and Southeast Asia (BNEF, 2026).

Higher natural gas prices in the main importing regions also strengthen the economic case for electrification of heating in buildings and industry, and for greater use of renewables and batteries in the power sector. Global buildings heat pump sales grew by about 2.5% year-on-year in the first half of 2026, and by over 10% in Europe, while global deployment of behind-the-meter battery storage increased by nearly 30%. Any faster deployment of larger-scale facilities, such as wind farms and grid-scale battery storage, will take longer to appear in the

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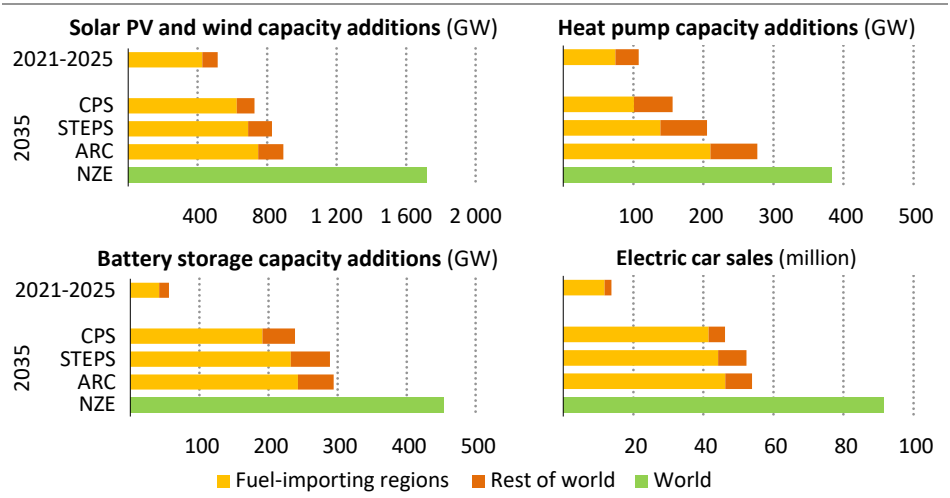
data. Many countries in fuel-importing regions, notably in Africa and Asia, have seen sharp rises in imports of electrification technologies, including batteries, electric cars and solar PV, from China in 2026, offering a further indicator of increased demand (IEA, 2026a).

This rise in clean technology deployment in oil- and gas-importing regions persists to differing degrees across our scenarios (Figure 1.6). This trend is most visible in the ARC, reflecting announcements by countries targeting specific technologies, as well as broader strategies such as those set out in the EU Electrification Action Plan. Outside these fuel-importing regions, additions in the next decade remain broadly similar across scenarios, except in the CPS, but they take place at a faster pace than over the last five years.

Figure 1.6 ▷ Annual additions of key technologies by scenario, 2021-2025 average and 2035



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The 2026 energy crisis could accelerate technology deployment, but the scale of the shift depends on the transition pathway and pace of investment

Notes: GW = gigawatt; PV = photovoltaics. Heat pump capacity additions correspond to the buildings sector.

While the acceleration in clean technology deployment is noticeable across all scenarios, particularly in fuel-importing regions, it remains well below the pace required in the NZE Scenario. By 2035, in the NZE Scenario, annual electric car additions reach around 90 million units, heat pump additions 380 gigawatts (GW), combined wind and solar capacity additions over 1 700 GW, and battery storage additions around 455 GW.

Higher energy prices, infrastructure damage and shipping disruption in the Strait of Hormuz have constrained Middle East supplies of feedstocks and industrial products as well as fuels. This has had a particular impact on the chemicals sector, disrupting fertiliser markets,

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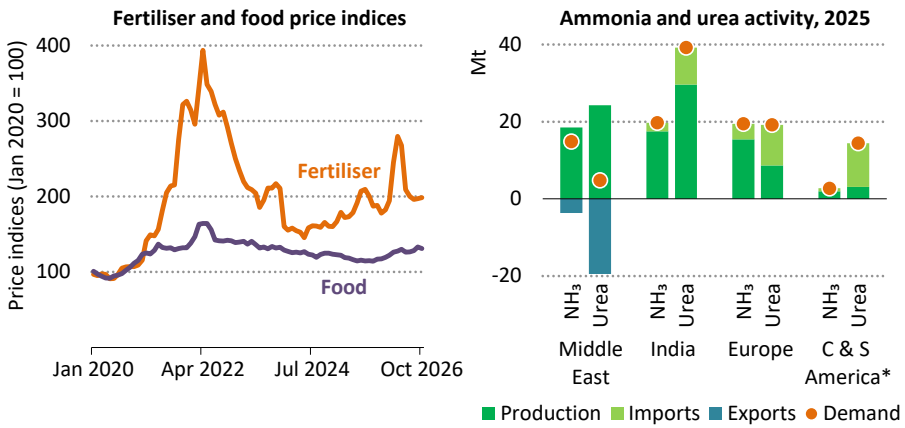
petrochemicals and wider industrial supply chains, and potentially strengthening prospects for green ammonia as a means to increase energy and food security (see Spotlight).

S P O T L I G H T

What are the implications of the 2026 energy crisis for fertiliser markets and food security?

The conflict in the Middle East has again exposed the link between energy and food security. Ammonia is the foundation of mineral fertilisers, which are used to produce 50% of the food consumed globally (IFA, 2023). Before the conflict, around one-quarter of global ammonia exports and 40% of global urea exports originated from the Middle East, with ammonia a key feedstock for nitrogen fertilisers and an input to urea production. Alternative supplies and trade routes helped cushion the initial impact of the conflict on prices and avoid immediate widespread fertiliser shortages. However, fertiliser and food prices were already elevated prior to the conflict (Figure 1.7), and prolonged disruption poses a growing and significant risk to food affordability and availability, particularly for import-dependent developing economies. Farmers unable to absorb additional costs and acquire supplies may reduce or delay fertiliser application, potentially impacting crop yields, food prices and food security.

Figure 1.7 ▷ Fertiliser and food price indices, 2020-2026, and demand, production and trade of ammonia and urea in selected regions, 2025



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Fertiliser price spikes have knock-on effects on food prices, with import-dependent regions more exposed to price shocks

Notes: Mt = million tonnes; NH_3 = ammonia. * Excludes Trinidad and Tobago.

Source: IEA analysis based on World Bank Commodities Price Data (2026).

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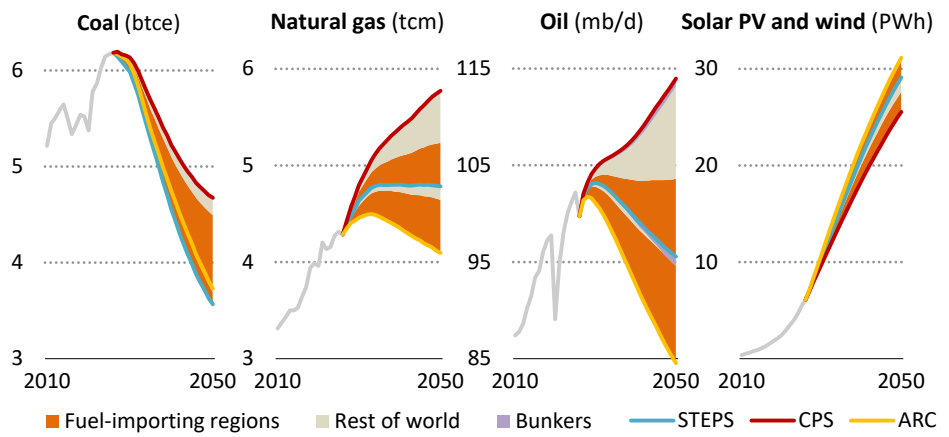
Over the long term, green ammonia from renewable electricity and hydrogen offers an opportunity for countries reliant on ammonia imports to strengthen their domestic fertiliser supply. Some countries are already investigating this opportunity. India is taking forward domestic green ammonia procurement for its fertiliser sector under the National Green Hydrogen Mission. Morocco, one of the world's largest importers of ammonia, has ambitions to utilise its renewable energy resources to produce ammonia domestically using electrolytic hydrogen. In Chile, green ammonia offers opportunities to reduce import reliance while growing industrial capabilities and supporting future export strategies. The uptake of green ammonia will depend on renewable resource availability and overcoming the challenging economics of green ammonia production.

Implications for fuel demand

Responses to the 2026 energy crisis, which vary across scenarios and cases, point to divergent fuel demand trajectories. The speed of electrification of end-use sectors is a key variable: it reduces oil consumption, particularly through the uptake of EVs, while limiting the growth of natural gas demand in buildings and industry. The pace of electrification, other energy efficiency improvements and the expansion of low-emissions fuels and sources of power have major implications for the primary energy mix and the rate of growth in total primary energy demand.

Figure 1.8 ▷ Fossil fuel demand and solar PV and wind generation by regional grouping and scenario, 2010-2050



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Fossil fuel demand follows diverging trajectories across scenarios, while solar PV and wind generation expands in all scenarios

Note: btce = billion tonnes of coal equivalent; tcm = trillion cubic metres; mb/d = million barrels per day; PWh = petawatt-hour.

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Oil demand follows different trajectories across scenarios, reaching 114 million barrels per day (mb/d) by 2050 in the CPS, compared with 96 mb/d in the STEPS and 85 mb/d in the ARC. In the STEPS, oil demand in oil-importing regions declines by 2030, while demand grows in the rest of the world (Figure 1.8). The CPS reflects a much slower pace of structural change, while the ARC sees much sharper reductions in fossil fuel demand. These differences highlight uncertainty over the lessons learned from today's supply disruption and price volatility, and whether they accelerate efforts to reduce import dependence through vehicle electrification, improved fuel efficiency and the use of alternative fuels. In the NZE Scenario, oil demand falls to 28 mb/d by 2050.

Natural gas demand continues to rise in the CPS, reaching approximately 5 800 billion cubic metres (bcm) by 2050, while levelling off at around 4 800 bcm from the 2030s onwards in the STEPS. In the ARC, demand peaks in the early 2030s before declining to 4 100 bcm by mid-century. In the NZE Scenario, demand falls to around 850 bcm by 2050. These pathways reflect differences in electrification, energy efficiency and low-emissions technology deployment; they also reflect infrastructure choices and, in particular, the extent to which developing economies, notably in Asia, commit to gas infrastructure development as a strategic priority.

While the measures adopted in the ARC bring oil and gas demand down from the levels projected in the STEPS, the same is not true for coal. Energy security considerations support a somewhat higher level of coal use in the ARC than in the STEPS, particularly in regions with abundant domestic resources and where high gas prices favour the use of coal (Box 1.2). They do not, however, reverse the long-term decline in demand. By 2050, coal demand falls to approximately 4 700 million tonnes of coal equivalent (Mtce) in the CPS, nearly 3 600 Mtce in the STEPS and 3 700 Mtce in the ARC; in the NZE Scenario, it falls to 500 Mtce.

Box 1.2 ▻ Is coal use benefiting from the 2026 crisis and, if so, how long might this effect last?

The renewed focus on energy security in 2026 is providing a near-term boost to coal utilisation and slowing some plant retirements, but it has not triggered a major new wave of coal-fired capacity. This is reflected in measures in Japan, Korea and Thailand to make greater use of existing coal-fired capacity, including by easing operating restrictions, delaying retirements or returning units to service, while Italy has postponed its coal phase-out. Existing coal-fired power plants can provide dispatchable electricity when other sources are constrained, particularly in countries with large domestic coal resources. Higher gas prices can also improve their relative competitiveness. But these effects vary substantially by region and do not overturn the longer-term direction of travel in the scenarios.

China is central to this story. Rapid growth in solar PV, wind and nuclear increasingly shifts coal-fired plants from providing bulk electricity towards meeting peak demand and providing flexibility, even as installed coal capacity continues to grow in the near term.

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Strong electricity demand growth in Southeast Asia means coal-fired generation continues to increase, but the region also sees increasing use of natural gas and a much larger contribution to power generation from solar PV and wind. In advanced economies, coal-fired generation continues to decline as existing plants retire, and low-emissions sources expand.

Existing fleets of coal-fired power plants can therefore offer some relief when other fuels are in short supply or become more expensive, while continuing to provide capacity and flexibility to power systems. But the continued expansion of low-emissions sources of electricity, reinforced by countries' policy responses to the recent crisis, signals a long-term decline in global coal-fired generation.

1.3 What does the 2026 crisis tell us about our ability to cope with oil supply shocks?

The world has been through several major oil supply shocks since 1970. The crisis in 2026 is by far the largest: at its peak, global oil supply fell by 16.1 million barrels a day (mb/d) from pre-conflict levels. The crisis is not yet over, so any conclusions about what it tells us are provisional. Nonetheless, it is possible to examine the main factors in play thus far.

Supply-side buffers

The effects of the first months of the crisis on the price of crude oil were more muted than those seen during previous disruptions and were less than might have been expected given the size of the disruption. A key reason was that the market was well supplied when the crisis began, with a large excess of supply over demand (Figure 1.9). This was driven in large part by buoyant production across the Americas, notably from the American quintet of the United States, Canada, Guyana, Brazil and Argentina. Another factor was the gradual unwinding by OPEC+ producers of production cuts over the course of 2025. Global oil supply exceeded demand by 2.2 mb/d in the second half of 2025, and observed inventories totalled more than 8 billion barrels.

Current OPEC members, excluding the United Arab Emirates (UAE), had around 2.6 mb/d of spare crude production capacity. However, virtually all of this was located in countries exporting oil through the Strait of Hormuz, eliminating what might otherwise have been a key buffer against potential supply interruptions. Instead, Gulf suppliers maximised the use of bypass routes, with Saudi Arabia redirecting exports through the East-West pipeline and via the Red Sea, while the United Arab Emirates sent crude south of the Strait of Hormuz via the port of Fujairah. This allowed Saudi and UAE oil exports to remain at over 60% of pre-conflict levels in the months following the outbreak of war, although these bypass routes have proved to be vulnerable to attack during the conflict.

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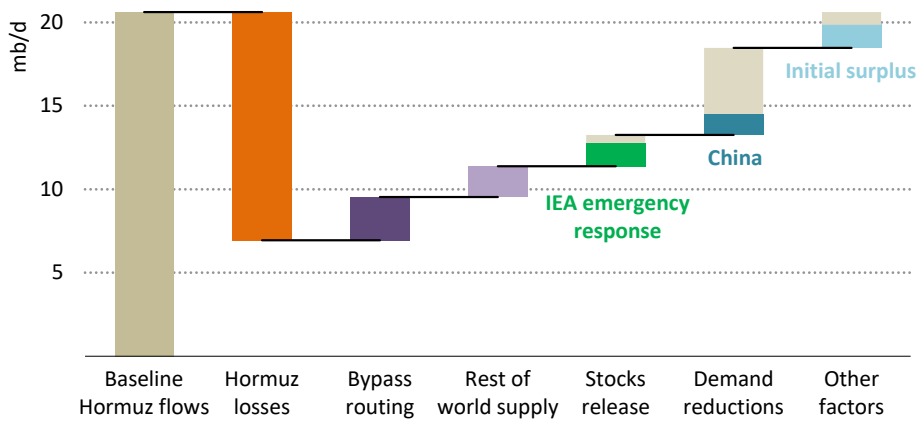
The world also drew on inventories at a record pace of 1.9 mb/d on average from March to October 2026. This stock draw, too, was a significant dampener on the escalation in price. These inventories were spread very unevenly around the world: many developing economies, notably in South and Southeast Asia and in Africa, were much more exposed to the risk of physical shortages than advanced economies and China. The IEA's co-ordinated stock release of 400 million barrels, announced early in the crisis on 11 March 2026, played a major role; by May, it was bringing 2.5 mb/d of additional oil to market. China, the world's largest importer of crude oil, also drew on ample stocks built up over several years.

Figure 1.9 ▷ **Changes to global oil balance following the onset of the 2026 energy crisis**



IEA. CC BY 4.0.

A variety of policy tools and market responses helped to absorb the immediate shock of the 2026 energy crisis

Notes: Values shown cover the period from March 2026 to October 2026. Baseline Strait of Hormuz flows are values for February 2026. Hormuz bypass includes Saudi Red Sea ports, UAE's Habshan-Fujairah pipeline, Iraq via Türkiye and Syria, and Iran's Jask Oil Terminal.

Despite showing an impressive ability to maximise yields of products in short supply, notably jet fuel and diesel, the refining industry emerged as a bottleneck in the oil supply chain. In addition to the loss of Middle Eastern product exports, attacks on Russian refineries drastically reduced their export of oil products, while Asian refinery output was disrupted by shifts in crude supply. Refined product markets are more fragmented than crude markets and are shaped by product specifications, refinery configurations and other regional constraints. They also have fewer buffers: inventories are smaller, and it is inherently more difficult to find substitutes for most oil products than for crude oil. As a result, disruptions in 2026 triggered much stronger price responses for oil products than for crude oil: in Northwest Europe, for example, a barrel of diesel in September 2026 cost around USD 85 more than a barrel of crude oil, four times the average differential seen in 2025.

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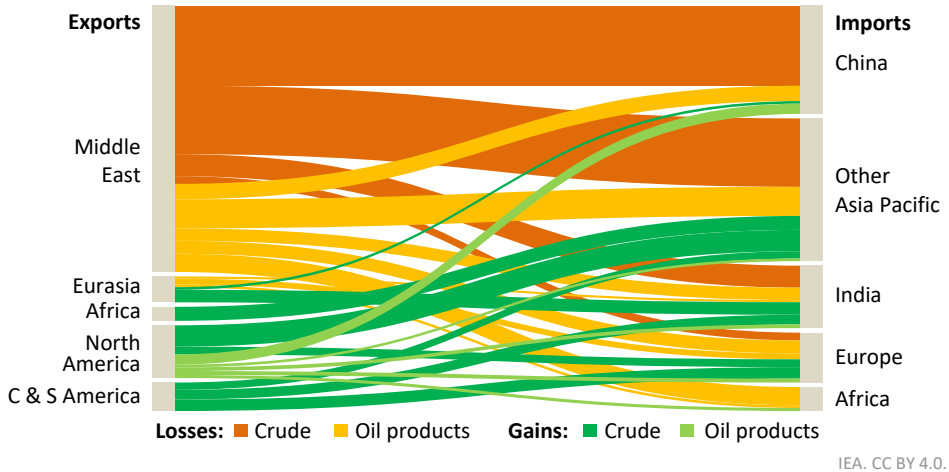
Notwithstanding these constraints, the global oil system demonstrated a remarkable capacity to adjust. As the most widely traded commodity globally, crude oil benefits from deep and liquid markets in which adjustments take place rapidly through innumerable decentralised decisions by suppliers, refiners, traders, and other market participants (Figure 1.10).

Figure 1.10 ▷ Changes in selected crude oil and oil product trade flows, March-August 2026 versus March-August 2025



The 2026 crisis led to a rapid redirection of global oil trade flows, with multiple actors playing a role in securing alternative pathways to meet crude and product demand

Source: IEA analysis based on Kpler (2026).

Demand-side adjustments

Between March and October 2026, oil demand fell by some 3.7 mb/d year-on-year. This reduction came about through a combination of higher prices, some physical constraints on availability, government-mandated demand-restraint programmes and lower levels of economic activity. Most of the reductions in demand occurred in the Middle East (-10%) and Asia (-5%). Demand in Europe was down by 2.3%, and in North America, it fell by less than 1%. The decline was concentrated in industrial products such as liquefied petroleum gas (LPG), ethane and naphtha, which were affected by large-scale disruption to Middle Eastern petrochemical operations and exports. Soaring diesel prices also weighed on gasoil use.

China reduced its seaborne crude oil imports by nearly 50% from 11.6 mb/d in February to around 6 mb/d in June 2026, and this played a key role in cutting demand. This reduction in imports was due to multiple factors, including a switch from building stocks up to drawing them down; the introduction in March of curbs on oil product exports; the use of fuel switching capabilities across the energy economy; and rising sales of EVs (Box 1.3).

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Box 1.3 ▻ Structural changes or short-term shifts? How oil demand is being avoided in the transport sector

The transport sector accounted for over 55% of global oil demand in 2025, with road transport alone responsible for around 43% of the total. Oil demand in road transport is closely linked to fleet size, kilometres driven and the deployment of more efficient vehicles.

Recent trends in EV sales, biofuels and plug-in hybrid usage point to growing structural shifts in oil demand. Global oil savings from EVs reached 1.8 mb/d in 2025 and are expected to rise to around 2.3 mb/d in 2026. Electric car sales outside China rose by around 35% from March to September 2026 compared with the same period in 2025, and sales increased by nearly 90% in Viet Nam, around 120% in India, close to 140% in Australia and over 170% in Brazil. Biofuels are another source of oil demand displacement: their use in 2025 meant that oil demand was over 2.5 million barrels of oil equivalent per day (mboe/d) lower than it would otherwise have been, and they are expected to displace a further 0.25 mboe/d in 2026, mainly with increases in the United States, Indonesia and India.

Beyond these structural shifts, there has also been scope for shorter-term savings from modal shifts, such as increased use of rail, cycling or electric taxis, and from action to maximise the efficient use of vehicles. A 10% increase in the use of electric mode in today's global fleet of plug-in hybrid vehicles could lower oil demand by up to 70 thousand barrels per day (kb/d), for example. A 2% shift from diesel medium and heavy freight trucks to battery electric alternatives could reduce global oil demand by an additional 0.2 mb/d.

Over the past few months, China has demonstrated how a shift to EVs can deliver substantial oil savings. Although domestic EV sales[1] fell by more than 15% year-on-year in the first ten months of 2026, they proved more resilient than the overall car market, which contracted by over 20%, with non-EV sales falling by over 30%. EVs maintained a market share above 60% for seven consecutive months from April to October, reaching nearly 68% in October. Meanwhile, electric heavy freight trucks accounted for over 35% of sales in the first three quarters of 2026, while diesel trucks lost ten percentage points of market share. Gasoline car sales have fallen to around one-third of their peak, and electric medium and heavy freight truck sales combined are set to account for more than 35% of the market in 2026. Together, these shifts are expected to generate oil savings from EVs of around 1.5 mb/d in 2026, with 75% coming from reduced use of gasoline and 25% from diesel (Figure 1.11).

These developments extend beyond China, with strong EV sales growth across Australia, Central and South America, Southeast Asia, Korea and Europe.

[1] Sales are the number of new vehicles entering the vehicle fleet and exclude used cars.

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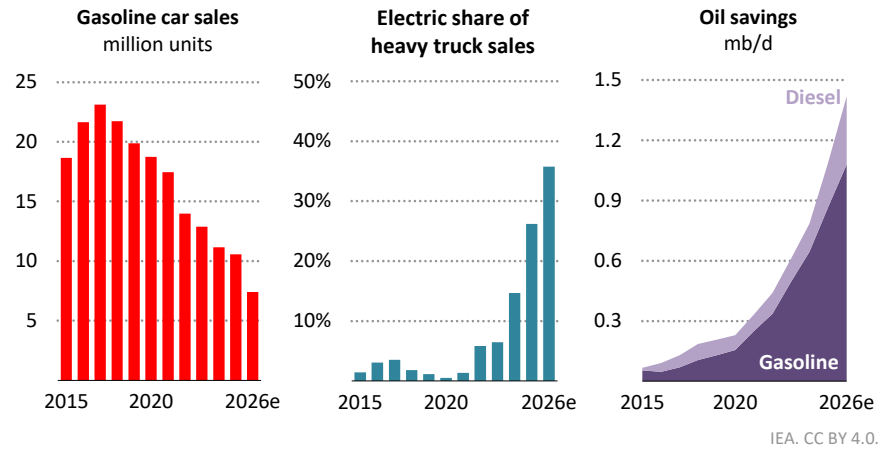
Figure 1.11 ▷ **Gasoline car sales, electric share of heavy truck sales and oil savings from EVs by oil product in China, 2015-2026e**



Gasoline car sales in China have fallen to a third of their peak, while electric heavy trucks are set to exceed 35% market share, cutting diesel demand by around 250 kb/d

Notes: 2026e = estimated values for 2026. Gasoline cars include both conventional internal combustion engine vehicles and non-plug-in hybrid vehicles. Heavy trucks include medium and heavy freight trucks.

Implications for the future

The energy system has become more resilient since the 1970s, but this should not disguise the fact that the shock came about at a moment when oil supplies and inventories were abundant, providing sufficient flexibility to avoid worse outcomes for a few months. These favourable starting conditions should not be taken for granted, or regarded as capable of providing a lasting reprieve in the face of such a large disruption. The available buffers have eroded as stocks continue to be drawn down, and alternative supply routes such as the East-West pipeline and the Bab el-Mandeb Strait face growing threats. This has increasingly left demand destruction brought about by high prices as the main avenue to balance supply and demand. The broader effects of high oil prices – inflation, higher debt, greater uncertainty around growth – have also begun asserting themselves.

The crisis has also underlined that absorbing an oil shock requires multiple adjustments on the supply and demand side, especially when the pressure points shift from crude supply to refineries, shipping, logistics and specific end-products. A well-functioning market can signal where these pressures are most acute through changes in price differentials and other market signals. Conversely, interventions such as trade restrictions or untargeted price support make this adjustment more complicated, often shifting the burden onto other market players less able to cope.

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The crisis has also demonstrated the value of alternative routes to market: for example, during the first few months of the 2026 crisis, Saudi Arabia's East-West pipeline preserved an estimated USD 60 billion in revenue, an amount far exceeding its construction cost. It has at the same time underscored the importance of emergency preparedness and oil stocks, as exemplified by the IEA collective action in March 2026, and the enduring value of co-operative approaches to oil security. Meanwhile, the uptick in EV sales has highlighted structural alternatives to oil for mobility that were not available at scale in the past. While EVs cannot replace gasoline- and diesel-fuelled vehicles overnight, the rise of electric mobility does mean that countries now have increasing scope to incentivise the use of EVs in order to better protect themselves over time from fuel price volatility.

That said, the impacts of the crisis have thus far been very asymmetric, both across countries and within them. Lower-income fuel-importing economies, particularly those with scarce foreign currency reserves, are less able to compete for available supply. Poorer segments within societies are more vulnerable to the effects of high prices: for example, in advanced economies, spending on energy accounts for around 20% of the disposable income of the bottom income quintile of households, and higher prices make it harder to cover basic energy needs. These distributional implications of oil shocks could become even more visible in the future if wealthier countries and households migrate away from oil use before poorer ones.

Finally, the crisis shows that stability in the Middle East continues to be vital for global energy security and energy markets, even if the security value of its spare capacity and the location of its oil stocks will need to be reassessed in the aftermath of the crisis. The region's role has evolved as global energy demand and supply have shifted, particularly as the US shale revolution and the rise of China and other Asian economies have redirected Middle East oil and gas exports eastward. This role continues to evolve in our scenarios in response to rising domestic energy needs, changing domestic policy priorities, increasing electrification of end-uses, the growing use of clean energy technologies and many other factors. The Middle East has been and remains a cornerstone of global oil and gas supply, a major provider of market flexibility, and a cost-competitive producer of many other energy and energy-related commodities. But it is also a source of potential risk that the rest of the world cannot fully insulate itself from.

1.4 How fast could electrification go?

In 2024, the IEA stated that the world was entering the Age of Electricity. Evidence of this shift has been accumulating. Since 2019, electricity demand has grown by 3.3% per year, faster than global gross domestic product growth (2.9% per year) and twice as fast as total energy demand growth (1.5% per year). This rapid increase in electricity demand is the result of rising demand from electricity-intensive sectors such as advanced manufacturing and AI, strong growth in the sales of electric equipment such as air conditioners, and the increasing deployment of electrification technologies like EVs and heat pumps.

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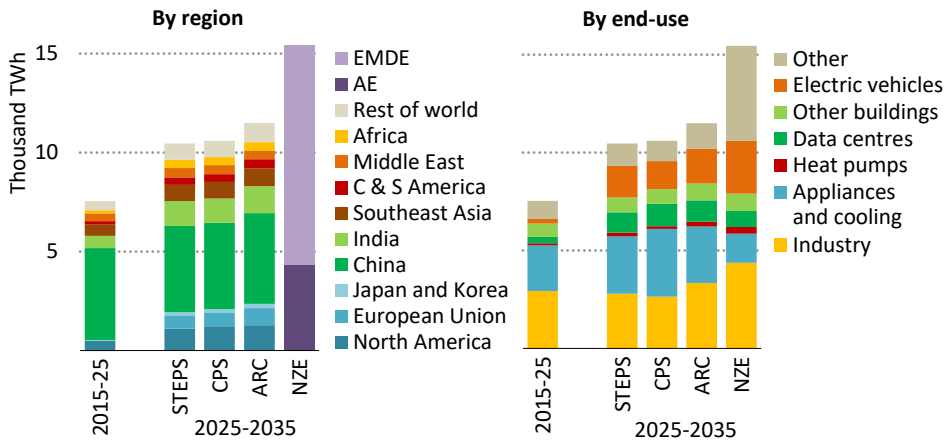
Electricity demand has grown by 7 500 terawatt-hours (TWh) since 2015. More than 60% of this demand growth has taken place in China, another 30% in other emerging market and developing economies, and less than 10% in advanced economies. Our scenarios see further strong growth in the next decade, with electricity demand increasing in all regions (Figure 1.12). Globally, demand grows by 10 500 TWh by 2035 in the STEPS – an increase as large as total electricity demand in all advanced economies today. It rises in the CPS by 10 600 TWh, in the ARC by 11 500 TWh and in the NZE Scenario by 15 500 TWh.

Figure 1.12 ▷ Global electricity demand growth by region, end-use and scenario, 2015-2035



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Electricity demand grows rapidly in all regions and scenarios, but the extent and make-up of demand growth vary by both region and scenario

Notes: TWh = terawatt-hour; AE = advanced economies. Other includes agriculture, non-road transport and other energy sector.

Electricity demand in advanced economies increases by 2% annually in the STEPS, and these regions account for almost 25% of demand growth over the next decade. The last time advanced economies contributed more than 20% to demand growth over a decade was before 2010, after which their share fell below 10% as demand stagnated and China's demand expanded rapidly. In the next decade, China accounts for less of the total than over the last decade, but it still drives more than 40% of overall demand growth. In emerging market and developing economies outside China, electricity demand growth accelerates: they are responsible for 35% of the increase in demand during the next decade, and electricity demand increases each year on average by 6% in India, 5% in Southeast Asia, more than 4% in Africa and 3% in the Middle East and in Central and South America.

Across all scenarios, demand for energy services powered by electricity rises quickly. By 2035, the stock of air conditioners grows by 45%, and the appliance stock expands by 2 billion units.

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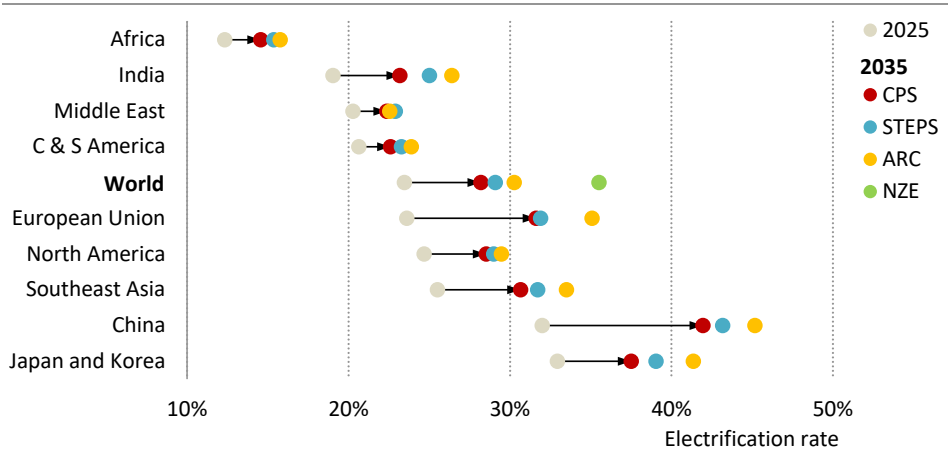
Driven by AI and digital services, data centre capacity almost triples. Other common drivers of electricity demand growth include EVs in China and the European Union, heat pumps in China and Japan, and the electrification of industry in China and the European Union, driven by growing cost-competitiveness (Box 1.4). While global electricity demand reaches similar levels in the CPS and STEPS, the composition is different: slower electrification in the CPS is offset by limited efficiency gains on appliances, cooling and industrial motors. In the ARC, end-use electrification accelerates further in oil- and gas-importing regions because of energy security concerns: by 2035, heat pump sales are 50% higher in importing regions than in the STEPS, and EV sales 10% higher. In the NZE Scenario, end-use electrification accelerates more rapidly than in the ARC, but it is combined with stronger energy efficiency measures which contain electricity demand growth for cooling and appliances, in particular.

In the STEPS, the global electrification rate (the share of electricity in final energy consumption) grows to 29% by 2035, up from 23% in 2025. Lower efficiency and electrification in the CPS mean that the electrification rate remains one percentage point lower than in the STEPS. In the ARC, the electrification rate in oil- and gas-importing regions reaches 38% by 2035, two percentage points higher than in the STEPS, and the global level reaches 30%. In the NZE Scenario, the global level reaches 35% by 2035 (Figure 1.13).

Figure 1.13 ▷ Electrification rate by region and scenario, 2025-2035



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Electrification rates rise in all regions, but they rise fastest in Asia and Europe; the global electrification rate reaches 35% by 2035 in the NZE Scenario

Electrification accelerates in all regions. The electrification rate in the European Union grows from 24% today to 32% by 2035 in the STEPS and to 35% in the ARC as heating, industry and transport electrify rapidly on the back of the EU Electrification Action Plan. East Asia, which already has a high rate of electrification, sees it rise further across sectors. While electrification also increases in Africa, continued gaps in access to modern energy, including electricity, keep its rate lower than in other regions.

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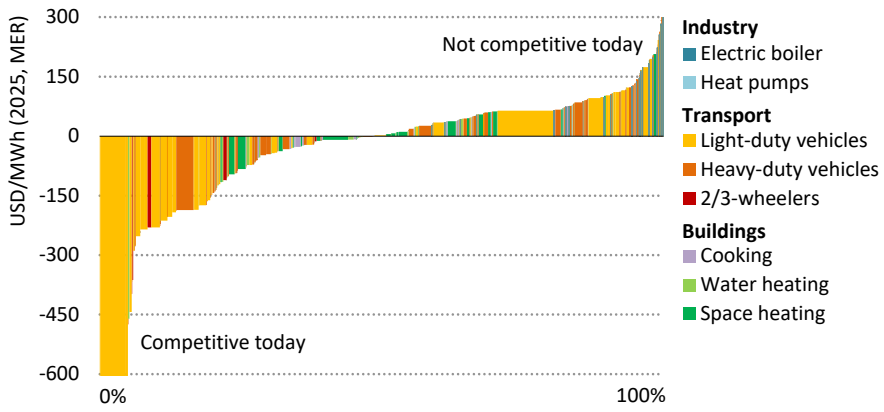
Box 1.4 ▷ Is electrification competitive?

The economic potential for electrification is determined by numerous factors, including the relative prices of electricity and competing fuels, technology costs, and financing conditions. These factors vary from one country to another because of significant differences in energy taxation regimes, costs of generating electricity, technology costs and interest rates. As a result, an electric technology that is economically competitive in one place, or even on average in the world, is not necessarily competitive everywhere.

We analysed electrification configurations across more than 900 country-specific variables to estimate the global cost-competitive potential for electrification, using energy prices, technology costs and financing conditions as they were in 2025. Our analysis finds that there is cost-competitive potential to electrify nearly half of road transport fossil fuel demand, around half of global fossil fuel-based space heating demand, and over one-third of global fossil fuel-based demand for low- and medium-temperature heat in industry. This means that the global electrification rate could reach 33% on a cost-competitive basis (Figure 1.14).

Figure 1.14 ▷ Global economic potential for electrification by end-use, as a share of fossil fuel-based energy consumption, 2025



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There is substantial cost-competitive potential for electrification based on today's technology costs, energy prices and financing conditions

Notes: MER = market exchange rate. MWh = megawatt-hour. The electrification potential curve displays the share of fossil fuel-based consumption that can be electrified at different electricity price premiums (computed against the local electricity price for the sector as a reference). Traditional use of biomass is not included. A negative premium means that electrification is cost-competitive. The levelised cost of technologies is assessed at a regional level based on local electricity and fossil fuel price, discount rate, investment cost and utilisation rate. Light-duty vehicles include passenger cars and light commercial vehicles. Heavy-duty vehicles include buses, medium freight trucks and heavy freight trucks.

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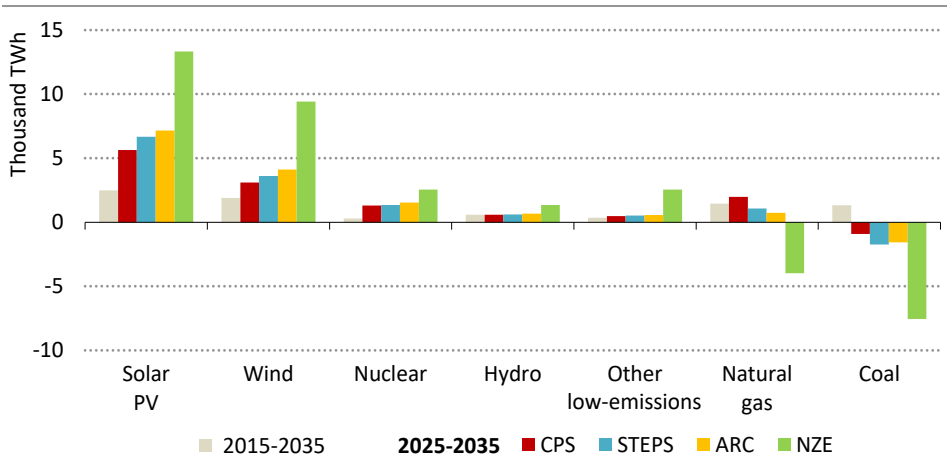
Non-cost barriers will, however, need to be tackled if the full cost-competitive potential of electrification is to be realised. These barriers vary by country, but they include a lack of adequate charging infrastructure for EVs, a low level of awareness of the long-term benefits of electrification, and the unreliability of electricity supply in countries where outages are common.

Can electricity supply keep up with growing demand?

Faster electrification requires electricity supply to expand alongside demand. Global electricity generation increased by around 8 100 TWh over the past decade and grows by a further 11 500 TWh to 2035 in the STEPS – over one-third of global electricity generation today. Generation increases by slightly more in the ARC, and the growth from 2025 to 2035 is over 16 300 TWh in the NZE Scenario.

Led by solar PV and wind, low-emissions sources have provided more than two-thirds of the increase in global electricity generation since 2015, with coal- and gas-fired generation accounting for the remainder. Renewables and nuclear power expand strongly in all scenarios to 2035, although the pace varies by scenario. In the STEPS, their combined growth exceeds the increase in total generation, effectively meeting all new demand and displacing some unabated fossil fuels. In the CPS, they meet most of the increase, leaving some of it to be met from fossil fuels. In the NZE Scenario, they grow faster than electricity demand and displace existing fossil-fuelled generation.

Figure 1.15 ▷ Growth in electricity generation by source and scenario, 2015-2035



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Low-emissions sources meet most or all additional electricity demand to 2035, but the supply mix varies by scenario and shapes the outcome for emissions and energy security

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Solar PV and wind provide the largest contribution to new supply, reflecting their improving cost-competitiveness and relatively short construction times (Figure 1.15). Nuclear power expansion reflects growing policy momentum and construction activities at their highest level in over 35 years. Hydropower and other dispatchable low-emissions sources remain important where conditions allow, and natural gas continues to provide additional generation and flexibility in some regions. The resulting supply mix has important consequences for emissions, fuel use and exposure to international energy markets. Storage, demand flexibility and other system resources become increasingly important as the share of variable renewables rises. These resources enable the better use of existing power capacity and network assets, reducing grid congestion and allowing electricity produced during periods of abundant supply to meet demand peaks. Faster electrification therefore increases the scale of the power system challenge, but it also brings new sources of flexibility that can help manage it.

The technologies needed to meet rising electricity demand are available, but some take longer than others to roll out. A central challenge is ensuring that deployment of these technologies keeps pace with rapid demand growth. Solar PV and battery projects can often be developed relatively quickly, while nuclear plants and major grid infrastructure have much longer lead times. The extent of the increase in electrification will depend on whether investment, planning, permitting and construction across generation, grids and flexibility can advance in a co-ordinated way at the pace required. Grids could prove to be a critical constraint (Box 1.5).

Box 1.5 ▻ Will grids be ready for the Age of Electricity?

Electricity grids risk becoming a significant constraint on how far and how fast electrification can proceed. Where expansion and modernisation fall behind, connection queues lengthen, congestion and curtailment rise, and electrification becomes slower and more costly.

Global electricity networks measure more than 85 million kilometres today. In the STEPS, this increases to over 110 million kilometres by 2035 as demand for electricity rises, and networks expand each year by about 30% more than they have over the past decade. This implies changes to some of the processes involved: at present, major transmission projects can take 5-15 years to plan, permit and complete, compared with 1-5 years for renewable power projects.

New lines remain essential, but existing networks also need to be used more efficiently. Digitalisation, dynamic line rating, reconductoring and power flow control can increase available capacity, while storage, demand response, smart charging and flexible connections can ease demand peaks and grid congestion. Grid-enhancing technologies could unlock 450-700 GW of additional hosting capacity, and flexible connections and other measures could enable a further 750-900 GW of demand to be connected to existing grids.

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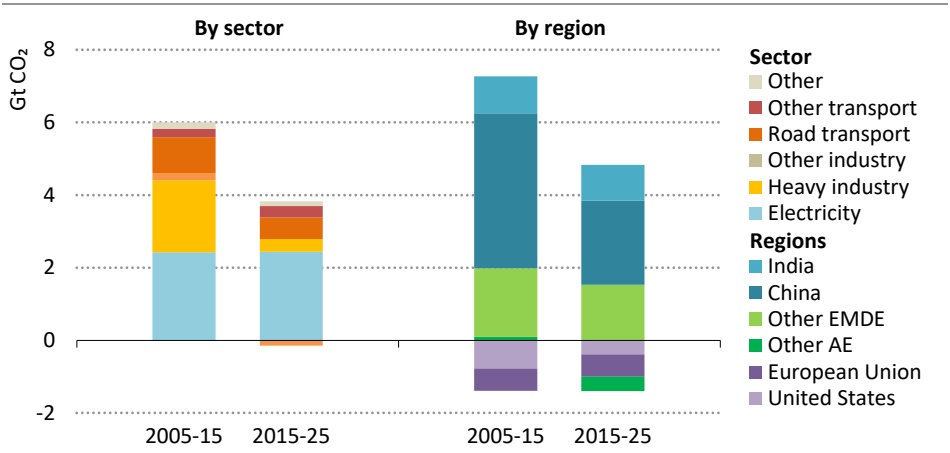
The principal challenge is implementation rather than a lack of available solutions. Anticipatory investment, streamlined permitting, reformed connection processes and co-ordinated planning of generation, grids, storage and demand could make better use of existing infrastructure, improve interconnections between neighbouring systems and accelerate the construction of new lines where these are needed. Progress on these fronts will determine whether grids enable or constrain the pace of electrification.

1.5 Are we on the verge of a peak in emissions and what will it take to bring them down?

Recent emissions trends

Global energy-related emissions are the largest contributor to climate change and have yet to peak. Between 2005 and 2015, they increased by around 6 billion tonnes (Gt), with the electricity and heavy industry sectors accounting for the great majority of this rise (Figure 1.16). In the decade following the adoption of the Paris Agreement in 2015, the rate of increase slowed. Despite rapid growth in renewables generation, increasing demand for electricity meant that emissions in the electricity sector increased by about 2.5 Gt between 2015 and 2025, in line with the increase in the previous decade. However, heavy industry emissions grew more slowly between 2015 and 2025 than previously, thanks to structural changes in China, which notably led to a decrease in its production of cement.

Figure 1.16 ▷ Change in energy-related CO_2 emissions by sector and region, 2005-2025



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The rate of emissions growth has slowed, but energy-related emissions have yet to see a structural decline

Notes: Gt = gigatonne; CO_2 = carbon dioxide. Other sector includes emissions from buildings, non-energy use and international bunkers.

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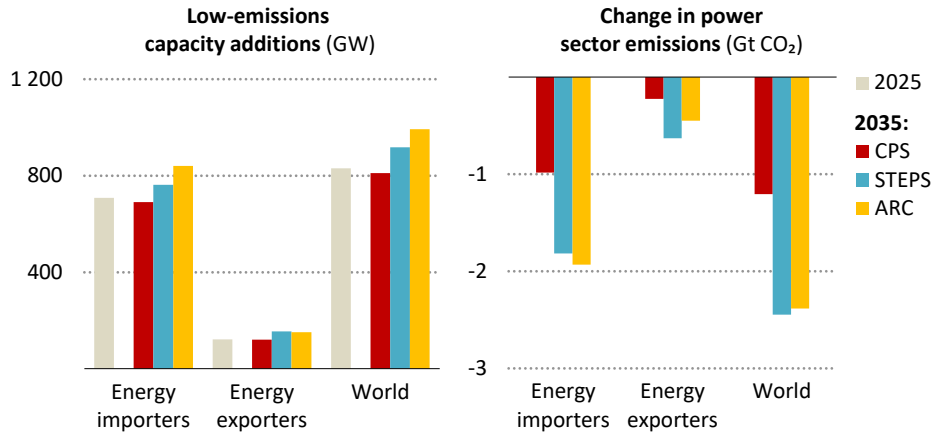
China has played an outsized role in the increase in global energy-related emissions in the last two decades, but the rate of growth of its emissions has slowed in recent years, and its energy-related emissions actually fell in 2025. Emerging market and developing economies outside China have also seen their emissions growth slow in the decade to 2025, while advanced economies have reduced their emissions by around 1.4 Gt in aggregate over the same period. The rise of technologies such as wind and solar PV has helped to bring about this overall slowing of emissions growth.

Could the 2026 energy crisis lead to a trend break?

In 2025, combined capacity additions of wind and solar PV totalled almost 790 GW (Figure 1.17). Annual averages remain close to this level to 2035 in the STEPS, rise to 860 GW in the ARC and fall to around 710 GW in the CPS. With nearly 90 GW of capacity under construction, nuclear power also grows strongly in the CPS, STEPS and ARC to 2035. Low-emissions capacity additions are sufficient to bring about a fall in electricity generation emissions of between 1.2 and 2.4 Gt between 2025 and 2035, with the size of the reduction depending on the scenario. In the ARC, a bigger increase in wind and solar capacity additions is offset by higher coal generation in some markets.

Figure 1.17 ▷ Low-emissions capacity additions by scenario in 2035 and change in power sector emissions between 2025 and 2035



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Continued annual additions of low-emissions electricity generation capacity at around the 2025 level are enough to bring about a decline in emissions from the power sector by 2035

End-use emissions in 2035 are about 22 Gt in the CPS and around 20 Gt in the STEPS and ARC. The largest differences are in the industry and transport sectors. In the CPS, efficiency improvements in industry are in line with their historical rate, while EV sales plateau at today's level in regions that do not have supportive policy frameworks. By contrast, industrial energy efficiency improvements accelerate in the ARC, and EV sales continue to rise in a

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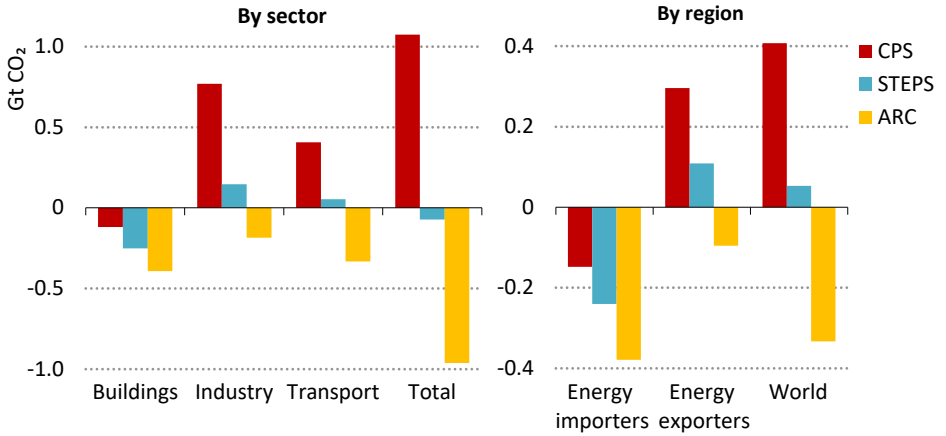
range of markets and vehicle segments. In the STEPS, end-use emissions decline in fuel-importing regions. This decline helps to keep overall end-use emissions broadly flat to 2035. In the ARC, stronger efficiency improvements and faster electrification in oil- and gas-importing regions push end-use emissions down further (Figure 1.18).

Figure 1.18 ▷ Change in energy-related emissions from end-uses by sector and region, 2025-2035



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End-use emissions diverge between scenarios, with key differences driven by the rate of efficiency improvements and the uptake of electric technologies

Total energy-related emissions decline by 2035 in the STEPS and ARC. The growth from the level of emissions in 2025 is marginal in the CPS, while the decline is pronounced in the STEPS (-6%) and the ARC (-9%). The main driver of this decline is the electricity sector. Because renewables are already competitive in many markets, their trajectory is less sensitive to emerging policy and market responses to the 2026 energy crisis than those of some other technologies, and it is shaped primarily by the speed with which electricity systems can adapt to integrate variable sources of supply.

Emissions fall further in the ARC than in the STEPS, largely because the ARC sees faster progress on electrification, efficiency and biofuels in oil- and gas-importing regions. There is a particularly strong alignment between clean energy transitions and energy security in these regions, but energy security considerations alone are not enough to bring about a decisive overall decline in global emissions.

What would it take to get on track for net zero emissions?

Limiting the rise in global temperatures means reducing emissions of carbon dioxide (CO_2) to net zero. The IEA's Net Zero Emissions by 2050 (NZE) Scenario represents one global pathway, but not the only one, towards achieving this objective by 2050.

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As countries enter into the second Global Stocktake under the Paris Agreement, it is useful to consider key milestones to 2035 and 2040 in the NZE Scenario (Table 1.1). In this scenario, global installed renewables capacity triples between 2025 and 2035 and continues to grow after that. Nuclear capacity also increases significantly, and bioenergy, low-emissions hydrogen and hydrogen-based fuels, and carbon capture all advance rapidly. Global installed transmission and distribution lines increase by more than 30 million kilometres over the same time frame. The share of electricity in total final energy consumption reaches 35% by 2035. Energy-related emissions are more than 50% lower in 2035 than today, while fugitive methane emissions fall by around 80% over the same period.

Table 1.1 ▷ Key indicators in the NZE Scenario for 2035, 2040 and 2050

		NZE Scenario		
	2025	2035	2040	2050
Installed renewables capacity (GW)	5 800	20 500	28 400	37 400
Installed nuclear capacity (GW)	420	730	980	1 200
Installed battery capacity (GW)	300	3 340	4 860	7 100
Installed transmission and distribution lines (million km)	86	120	140	190
Emissions intensity (t CO_2 per thousand USD)	0.17	0.06	0.03	<0.01
Share of electricity in final energy consumption	23%	35%	45%	61%
Share of EVs in passenger car stock	6%	36%	58%	87%
Heat pump sales (GW)	110	380	460	590
Share of unabated fossil fuels in total energy supply	72%	41%	23%	6%
Sustainable fuel supply (EJ)	7	33	45	64
Share of hydrogen and hydrogen-based fuels in total final consumption	<1%	1%	3%	5%
CO_2 captured (Gt)	0.1	2.2	3.9	6.4
CO_2 removed (Gt)	<0.1	0.7	1.2	2.7
Fossil fuel methane emissions (Gt CO_2-eq)	3.7	0.8	0.4	0.1
Fossil fuel upstream methane intensity (kg CH_4 per GJ)	0.19	0.06	0.04	0.01

Note: km = kilometre; CO_2-eq = carbon dioxide equivalent; CH_4 = methane.

The IEA's *World Energy Outlook 2025* (*WEO-2025*) recognised that high levels of emissions and continued investments in emissions-intensive infrastructure in recent years mean that it is no longer possible to avoid an overshoot of the 1.5 °C goal in the near term. The temperature rise exceeds this threshold by around 2030 in all IEA scenarios, including the NZE Scenario. By 2050, it reaches 2 °C in the CPS, 1.9 °C in the STEPS and the ARC, and just below 1.7 °C in the NZE Scenario (Figure 1.19). In this scenario, temperatures fall slowly below 1.5 °C above pre-industrial levels by 2100, and rapid emissions reductions in the next couple of decades lessen the need for negative emissions after 2050 from technologies that are still unproven at scale. Discussions during the second Global Stocktake process under the Paris Agreement could usefully consider the implications of an almost certain overshoot of 1.5 °C and what this means for future pathways and climate pledges (Box 1.6).

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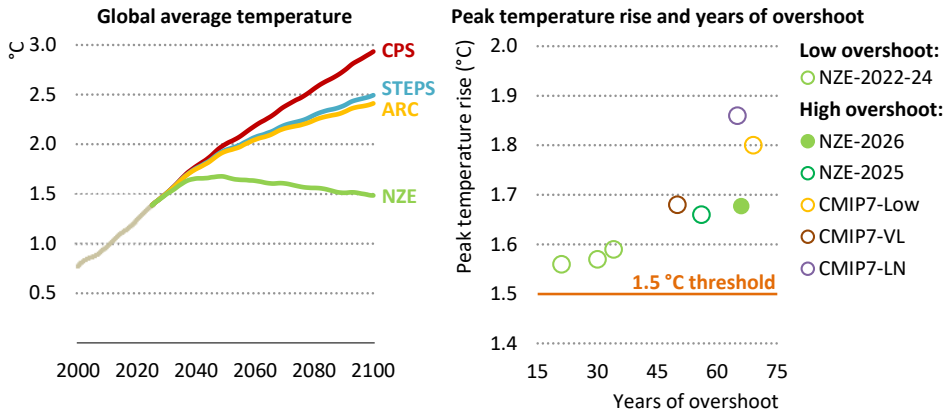
Figure 1.19 ▷ Global average temperature, peak temperature rise and years of overshoot in selected CMIP7 and IEA scenarios



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The average temperature rise in the NZE Scenario peaks just below 1.7 °C by 2050 and falls below 1.5 °C by 2100; a limited overshoot pathway to 1.5 °C has slipped out of reach

Note: CMIP = Coupled Model Intercomparison Project; VL = very-low; LN = low-to-negative.

Source: IEA analysis based on IIASA (2026).

Box 1.6 ▷ Do new climate pledges close the gap?

Since the adoption of the Paris Agreement, countries have progressively expanded their climate commitments. Updated every five years, Nationally Determined Contributions (NDCs) remain the primary mechanism through which countries communicate their near-term climate ambitions and set out economy-wide emissions reduction targets. As of October 2026, 136 Parties had submitted new NDCs under the latest submission cycle.

New NDCs do not point to a significant acceleration in energy-sector greenhouse gas mitigation compared with the previous submission cycle. At the global level, energy-related CO_2 emissions implied by the new NDCs decline by close to 0.5% per year to 2035, reaching around 31.2 gigatonnes of carbon dioxide in that year. This rate of decline is broadly comparable to, and in some cases weaker than, that implied by the previous round of NDCs submitted in 2020-2021, which pointed to annual emissions reductions of around 0.6% to 2030 (Figure 1.20). It nevertheless represents an advance on the level of ambition in the first round of NDCs submitted in 2016, which implied energy-related CO_2 emissions growth of around 1.1% per year to 2030.

This global picture masks important regional differences. Advanced economies have, in aggregate, strengthened their climate commitments, increasing the pace of annual emissions reductions from 1.5% to 6.1% between NDC submissions. However, more ambitious targets have also widened the gap with implementation through domestic

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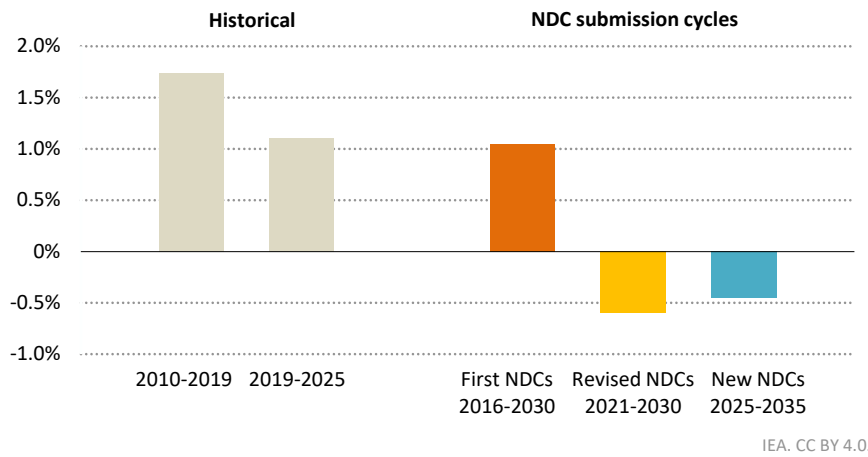
policies, underscoring the need for additional measures to deliver these outcomes. In emerging market and developing economies, ambition has largely stabilised, with NDCs implying a slight annual emissions decline of 0.3% in emerging markets and emissions growth of 2.3% in developing economies. In several regions, current policy frameworks are already broadly aligned with these targets.

Current NDCs remain insufficient to align emissions trajectories with the Paris Agreement temperature goals across all regions. This misalignment underscores the importance of the second Global Stocktake. In the NZE Scenario, energy-related CO_2 emissions decline by about 10% per year in advanced economies to 2035 and by 7% in emerging markets and 4% in developing economies.

Figure 1.20 ▷ Average annual change in energy-related CO_2 emissions implied by successive NDC submission cycles, 2010-2035



Notes: NDCs = Nationally Determined Contributions. The NDC of the United States is excluded, as the United States is no longer a Party to the Paris Agreement. International bunkers are also excluded.

1.6 What does energy security look like in tomorrow's energy system?

Vulnerabilities in traditional fossil fuel supply systems have been well understood for decades. Yet the 2026 energy crisis, coming so soon after the crisis triggered by the Russian Federation's (hereafter Russia) full-scale invasion of Ukraine in 2022, has exposed a number of these vulnerabilities in stark terms, and many governments are now recalibrating their policy priorities to strengthen energy security and affordability. The share of oil and gas in the global energy mix varies substantially between scenarios, but oil and gas are set to

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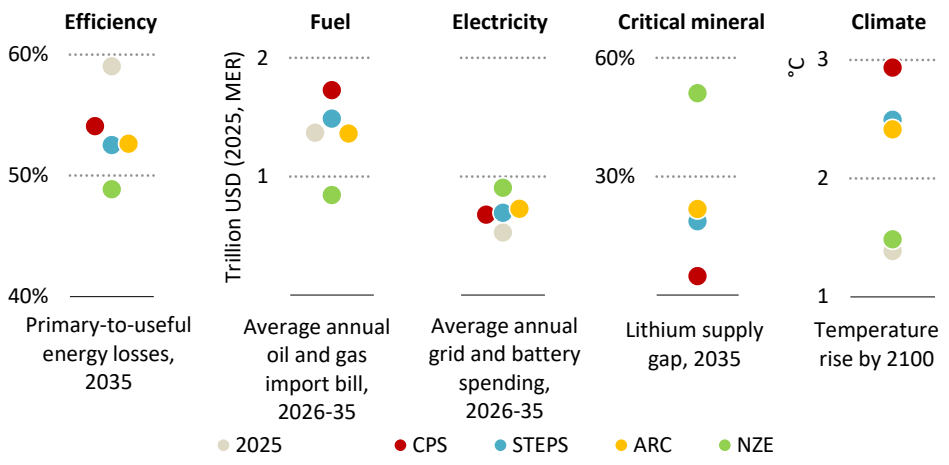
remain central to the energy mix in most countries for decades to come. Traditional fuel security risks may even increase if the balance between supply and demand comes under pressure. As countries weigh security priorities against other policy goals, they must also grapple with a new set of risks that reflect the evolution of energy systems and are centred on electricity security, critical mineral security and hazards that can suddenly disrupt or damage energy infrastructure.

Synergies, trade-offs and policy considerations

Some measures that strengthen energy security can also advance other policy objectives, but others involve trade-offs, and it is here that policy makers need to be clear-sighted on the implications and costs of their actions. For example, while electrification can reduce exposure to fossil fuel supply risks and bring down emissions, it cannot be pursued in isolation: without parallel efforts to diversify critical mineral supply chains and expand investment in low-emissions power generation, flexibility and grids, it may shift rather than reduce vulnerabilities.

Figure 1.21 ▷ Selected measures of efficiency and of fuel, electricity, critical mineral and climate security by scenario



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Faster electrification strengthens importers' fuel security and reduces climate risks but puts more pressure on electricity systems and critical mineral supply chains

Notes: pending and import bill values for 2025 refer to that year alone. The lithium "supply gap" measures the gap between projected demand and a supply outlook based on existing projects, those under construction, and those assessed as having a high chance of moving ahead by 2035. In 2025, lithium supply was sufficient to meet demand.

Our scenarios illustrate many of these trade-offs: for example, in the ARC, the enhanced push for efficiency and electrification cuts expenditure on oil and gas in importing regions by

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almost 40% compared with the CPS in 2035 (Figure 1.21). However, this requires around 15% more expenditure on electricity grids and battery storage than in the CPS, and it leads to higher demand for critical minerals. To take another example, efforts to improve energy security in the ARC mean more clean energy in some countries, but they also increase coal consumption relative to the STEPS in others. All scenarios run the risk of stronger and more frequent extreme weather events. However, the NZE Scenario limits the rise in global average temperature to a much lower level and therefore reduces this risk.

Fuels

Of the 6 billion people living in oil- and gas-importing countries, around two-thirds were dependent on flows through the Strait of Hormuz for more than 30% of their supplies before the 2026 crisis. Many importing countries are concerned about the risk of being over-reliant on particular suppliers and routes, and they are looking to boost fuel security by diversifying sources of supply (Box 1.7), maintaining and building emergency stocks, and reducing or limiting the growth in imports and import bills.

Box 1.7 ▻ Is international trade a problem or solution for fuel security?

Energy trade brings major benefits to an energy system, allowing importers to draw on resources that would be much more costly or impossible to produce domestically, and exporters to generate revenue and employment. Well-functioning international markets also bring energy security benefits by providing access to a large and flexible pool of energy resources that can be allocated efficiently in line with demand. However, over-reliance on imported fuels can create vulnerabilities, especially where there is a high degree of concentration among suppliers and of dependence on particular trade routes.

Over 40 mb/d of crude oil and 1 100 bcm of natural gas were traded internationally over long distances in 2025. In the CPS, these volumes increase for gas by more than 300 bcm and remain steady for oil by 2035, while they decline by 4 mb/d and 170 bcm in the ARC. Emerging market and developing countries in Asia drive much of the growth in the CPS, accounting for almost 60% of global fossil fuel imports in 2035 (five percentage points higher than in 2025). In contrast, imports into the European Union fall by 35% in the ARC, compared with a 17% decline in the CPS.

Diversification covers suppliers – sourcing imports from different regions, routes and risk profiles – and contracts – balancing suppliers, contract durations, pricing mechanisms and spot versus long-term purchases. Most of these measures carry a cost, especially compared with purchasing the lowest-cost source of supply, but they could be viewed as a form of insurance that is particularly valuable in a fractured international environment. Efforts to accelerate diversification in the ARC lead to a material improvement in the diversity of imports for most regions compared with the CPS and STEPS (Figure 1.22).

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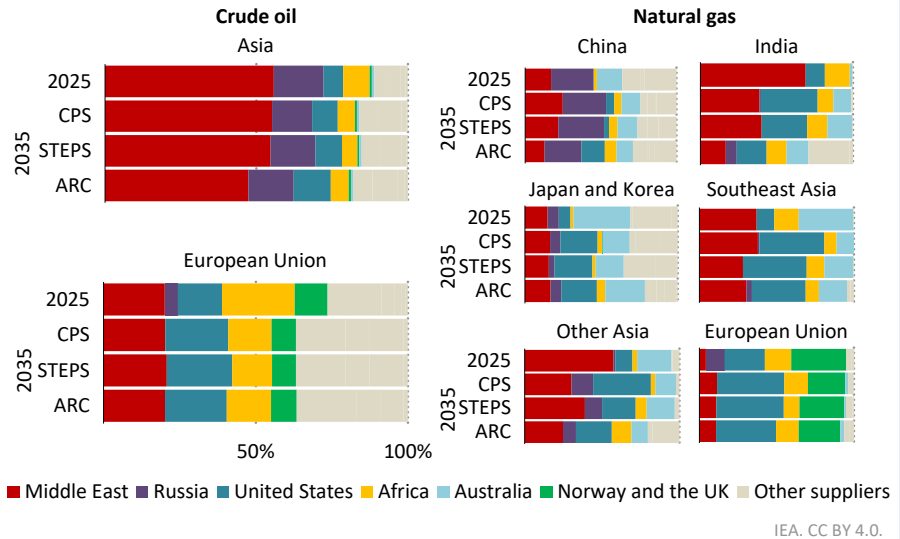
Figure 1.22 ▷ Crude oil and natural gas import shares in Asia and the European Union by origin and scenario, 2025 and 2035



Note: UK = United Kingdom.

Diversity requires a broad mix of suppliers, import routes and contractual arrangements, taking account of the reliability of trusted suppliers. A broad mix could reduce reliance on key maritime chokepoints, including the Straits of Hormuz and Malacca, but it is not sufficient as a safeguard against unexpected events. Emergency stocks are also needed to provide buffers against disruptions to the supply of both oil and natural gas. These buffers are most effective when supported by institutional capacity – such as that provided by the IEA – to monitor markets closely, respond rapidly and build consensus on necessary action in the event of a supply shortfall, as illustrated in 2026.

The need for imports can be reduced by measures that improve energy efficiency and support electrification, supplemented where feasible by domestic energy production, including the production of low-emissions fuels (Figure 1.23). The ARC shows what full implementation of measures under consideration in fuel-importing regions could mean. For example, net gas importers see a 40% increase in natural gas imports to 2035 in the CPS and 25% in the STEPS, but imports fall by around 10% in the ARC. More than 75% of the reduction in imports in the ARC beyond the STEPS is achieved through demand-side measures, with increased domestic production of coal and natural gas responsible for the remaining 25%.

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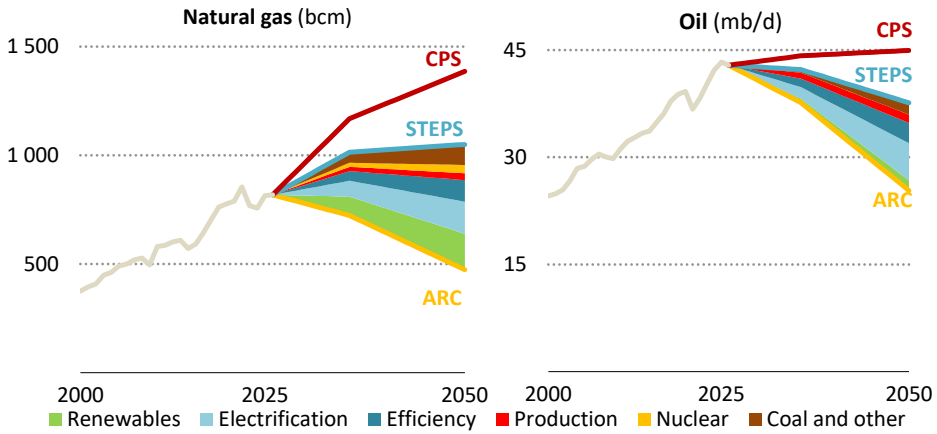
Figure 1.23 ▷ Natural gas and oil imports by net importers in the CPS, STEPS and ARC, and drivers of the differences between the STEPS and the ARC, 2000-2050



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In the STEPS, gas imports by net importers rise by 25% by 2050, while oil imports fall by 15%; in the ARC, electrification and efficiency improvements reduce imports

Note: Other includes nuclear and coal.

Electricity

Electricity already underpins more than 45% of global economic activity, and this rises to around 55% by 2035 in all scenarios. Electrification reduces exposure to internationally traded fuels, but it also increases the economic and social consequences of electricity disruptions. As demand grows and electricity systems become more complex, security increasingly depends on four interlocking requirements: adequate capacity to meet peaks, flexibility to balance supply and demand, robust grids and operations, and a diverse mix of resources with different operating and security characteristics.

Adequacy means having sufficient resources to meet demand at all times. Peak electricity demand rises from around 4 700 GW today by about 40% in the CPS and STEPS to 2035 and by 50% in the NZE Scenario. Ensuring adequacy as demand increases is particularly challenging during periods when high demand coincides with low wind and solar output. Fossil fuel power plants, hydropower and nuclear remain important at such times, while batteries and demand response meet a growing share of peak residual load. This broadens the range of resources available, although continued reliance on thermal power means that secure fuel supplies remain important for electricity security.

Flexibility keeps supply and demand balanced over periods ranging from hours to seasons, and the requirement for flexibility is set to increase rapidly in all scenarios. Short-term needs rise to between two and two-and-a-half times their current global level by 2035 in the CPS

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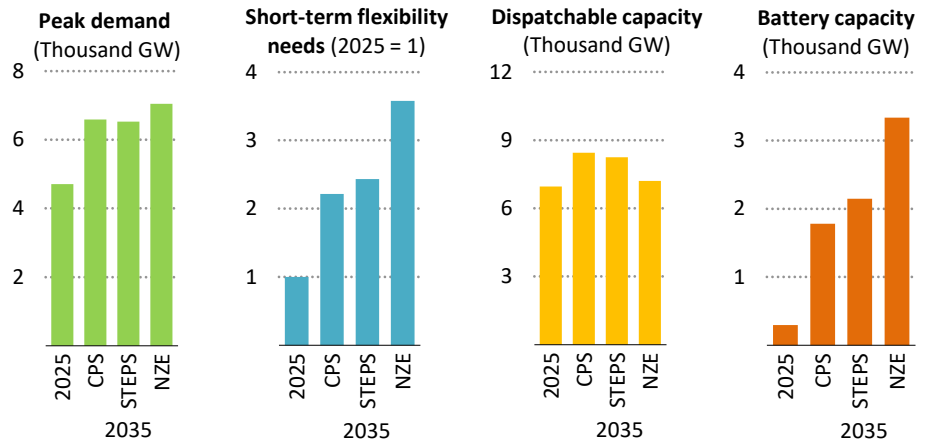
and STEPS (Figure 1.24), while seasonal needs also grow. Hydropower and thermal plants remain important, particularly for seasonal balancing, but other sources also play an important role: batteries provide between 30% and 40% and demand response around 20% of short-term flexibility in both scenarios by 2035. Grids and interconnections complement these resources by balancing variations across wider areas, while some renewable curtailment can be more economic than building enough storage and network capacity to absorb every unit of output.

Figure 1.24 ▷ Electricity security requirements and resources by scenario, 2025 and 2035



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Peak demand and flexibility needs rise in every scenario, requiring adequate capacity, robust grids and a broad range of flexible resources

Note: Dispatchable capacity includes generating capacity only.

Robustness depends increasingly on the strength and operation of electricity grids, and grid planning and delivery need to keep pace with changes in supply and demand. Better use of existing networks, including through digitalisation and grid-enhancing technologies, can accelerate connections, but rising demand also calls for grid repairs, replacements and expansion. Ageing or congested networks create risks of local outages, connection delays and curtailment, and around 16 million kilometres of grid assets require replacement or major refurbishment by 2035. Expansion and modernisation need to be accompanied by investment in system stability, monitoring, control and cyber security.

Diversity limits reliance on individual technologies, fuels and supply chains. Generation mixes become more diverse in many regions as renewables and nuclear expand alongside continued contributions from fossil fuel generation. Each source brings different strengths and vulnerabilities. Fossil fuel generation depends on secure fuel supplies; wind, solar PV and hydropower are exposed to weather conditions; nuclear power has specific fuel, cooling and

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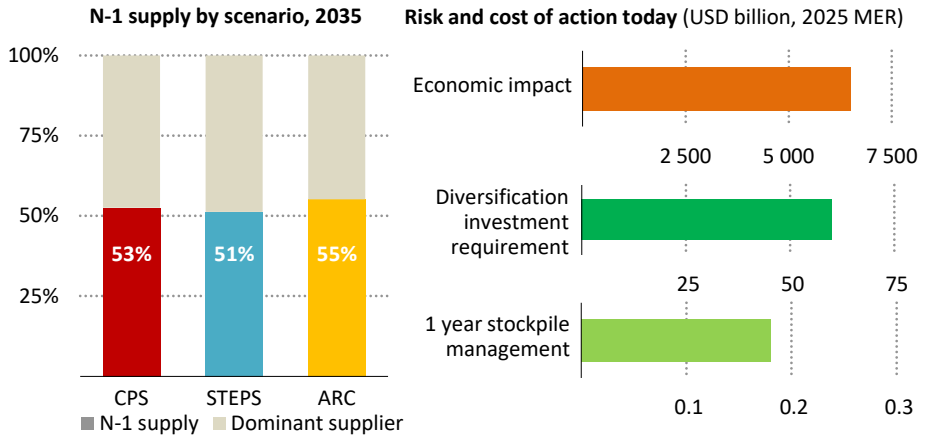
operational requirements; and low-emissions technologies depend on concentrated equipment and mineral supply chains. Diversity strengthens security when these resources have complementary characteristics and are supported by storage and flexible demand.

Capacity, grids, storage, demand response and operational capabilities need to advance together. In all scenarios, electricity security rests on sequencing investment effectively: retiring existing assets that provide adequacy and flexibility before alternatives are available would create new vulnerabilities, but delaying the deployment of those alternatives would leave systems exposed to fuel shocks, congestion and rising flexibility needs.

Critical minerals

Critical mineral supply chains represent a growing risk to energy security as demand for clean energy technologies rises. The risk is greatest for refining, which is generally more geographically concentrated than mining. Rare earth elements illustrate the challenge: they are essential for permanent magnets used in EVs, wind turbines, defence systems and other advanced technologies, yet the largest country producer accounts for around 85% of magnet rare earth refining.

Figure 1.25 ▷ Rare earth N-1 supply security by scenario in 2035, and cost of disruption versus insurance investment today



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Rare earth supply without the largest producer falls short of demand in all scenarios, and the cost of insuring against disruption is a fraction of the value at risk today

An N-1 assessment for 2035 illustrates the vulnerabilities in supply diversity and robustness.[2] In the CPS, refining capacity outside China, the largest producer, meets around 53% of

[2] An N-1 assessment excludes the largest producer and measures how much of the remaining demand can be met by the remaining supply; a higher value indicates greater robustness.

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magnet rare earth demand outside China (Figure 1.25). This number is lower in the STEPS, in which more rapid clean energy deployment raises demand faster than rare earth capacity outside China expands. The ARC sees the situation improve as a result of efforts to manufacture equipment in a wider range of locations and to diversify the sourcing and processing of minerals.

The costs of inaction could far exceed those of building more secure supply chains. A major rare earth supply shock could put more than USD 6 trillion of annual downstream production at risk, compared with an estimated USD 60 billion of investment needed to diversify supply. Mobilising this investment requires financial and policy support for projects, accelerated efforts to enhance price transparency, and policies to unlock the full potential of recycling. Co-operation between international partners would make it easier to move forward.

Diversification will take time, making preparedness equally important. Stockpiles can play a role in improved flexibility: the net cost of maintaining a one-year import stockpile of rare earth products is estimated at around USD 200 million across all exposed countries combined, which is very small compared with the economic value at risk. Building such buffers while diversified supply chains are developed would provide flexibility to absorb shocks and sustain essential downstream production.

Resilience

Even with plans to reduce long-term fuel, electricity and critical mineral vulnerabilities, systems must be prepared for natural hazards and malicious attacks that disrupt the normal operation of energy infrastructure.

Since 2022, around 3 000 major outages linked to natural hazards have been reported globally, affecting more than 850 million households and businesses. Electricity systems are particularly vulnerable due to their reliance on exposed infrastructure and the need to maintain a continuous balance between supply and demand. Storms and floods cause many outages, but they are the second leading cause of weather-related disruption, after extreme heat and droughts which have led to rolling blackouts that account for nearly 60% of customers disrupted since 2022 (Box 1.8).

The risk of malicious acts such as physical attacks and cyber threats is increasing. Since 2022, energy assets have been the target of more than half of attacks on civilian infrastructure in the Middle East and nearly one quarter of Russian attacks in Ukraine. Meanwhile, cyber-attacks on energy utilities worldwide have risen as energy systems have become more digitised and programming tools more accessible, with more than 2 000 attacks per week in 2025 (Check Point, 2026).

These disruptions translate into wider economic losses and call for additional measures and investments in monitoring, system design, hardening, robust operations and recovery. By November 2026, 19 G20 countries had adopted infrastructure-specific resilience requirements for energy assets, established inspection and maintenance obligations, and mandated emergency preparedness plans: the challenge now is to implement these measures.

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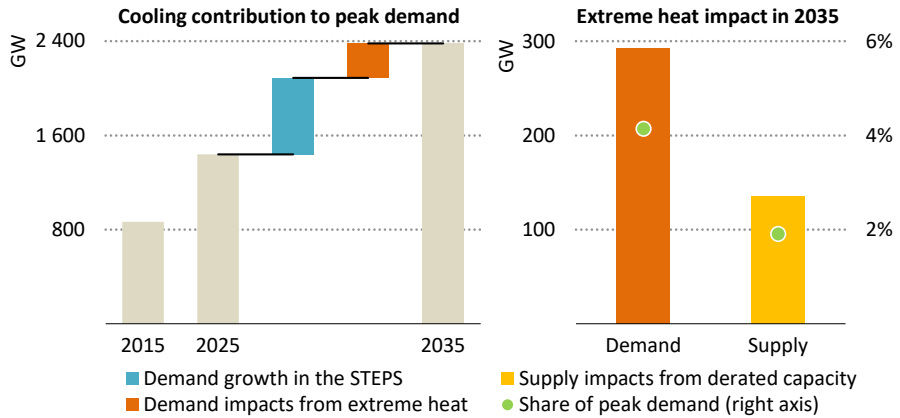
Box 1.8 ▷ Heatwaves and resilience

August 2026 was the hottest month globally on record, and 2026 saw exceptional heatwaves in several countries: in Austria, Belgium, France and Germany, for example, the number of cooling degree days[3] between May and August 2026 was three times historical levels. Increased exposure to extreme heat is set to accelerate the ownership and use of air conditioners (ACs) and to decrease electricity generation and transmission capacity at the same time, making it more difficult to meet peak electricity demand. In the first half of 2026, more than 60 million customers experienced electricity system outages related to high temperatures. Heatwaves also bring an increased risk of wildfires that threaten electricity networks, and of droughts that lower water levels, reducing hydropower output, complicating thermal generator operation and hindering inland waterway tanker and barge shipping.

Figure 1.26 ▷ Impact of extreme heat on peak electricity demand and supply in the STEPS, 2035



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Rising AC use and temperatures mean cooling accounts for 30% of peak demand in 2035, while extreme heat could add 4% to peak demand and cut supply by 2%

Note: Extreme heat impact corresponds to the difference between the median and the average of the top three peak demand values across 30 years of weather data.

In the STEPS, rising average temperatures and increased use of ACs add around 650 GW to peak electricity demand globally in 2035, and the increased intensity of periods of extreme heat pushes this up by a further 300 GW (Figure 1.26). At the same time, the derating of thermal power plants on the hottest days could reduce available thermal

[3] Cooling degree days are a measure of cooling needs, quantifying how much local temperatures exceed a threshold temperature (21 °C) over the year.

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generation capacity globally by up to 2% of peak demand in 2035. Together, these impacts could erode one-third to one-half of typical reserve margins, if the effects of extreme heat are not fully taken into account in system planning.

1.7 Are we heading for a world of energy abundance or energy scarcity, and what will this mean for prices?

Could we quickly revert to a comfortable oil and gas balance post-crisis?

Before the conflict in the Middle East began, the world looked to be heading towards a period of well-supplied oil and gas markets. Oil prices were trading at around USD 65/barrel, and global gas markets were expecting a wave of new liquefied natural gas (LNG) supplies. The prospects for a return to this kind of market environment hinge on a judgement about the duration of the crisis. We assume an easing of constraints on Gulf oil and gas exports as the world moves into 2027, but there is huge uncertainty over the timing of this shift and what a "new normal" for Gulf exports might look like. It is unclear whether oil and gas exports via the Strait of Hormuz will return to pre-crisis levels, let alone exceed them. There are likewise major open questions as to whether the crisis leaves a lasting imprint on policy choices, investment decisions and consumer preferences.

In the CPS, there is little scope for a long period of easing in oil and gas markets even with a rapid resolution to the 2026 crisis. Oil demand rises to 106 mb/d by 2035, 3% higher than in 2025. With anticipated declines in existing production, new projects are required to fill the gap. A key focus is on removing obstacles to supply growth, including by reviving production in Venezuela and sanctioning new developments in both OPEC and non-OPEC countries. Around 10 mb/d of production is anticipated from approved projects by 2035, of which around half is set to come from outside the Middle East (section 1.9). This new supply helps offset declines elsewhere, but around 17 mb/d of additional, as-yet unsanctioned supply is required. Oil markets in 2035 are balanced at around USD 85/barrel, and prices rise in the long run to more than USD 100/barrel by 2050. On the gas side, around 350 bcm of new LNG supply is set to enter markets between 2025 and 2035 (of which around 30% comes from expansions to Qatari and UAE capacity). This new supply is fully absorbed in the CPS, with gas prices in key importing regions averaging above USD 10 per million British thermal units through to 2050, reflecting the long-run marginal cost of delivering LNG, including the full capital costs of liquefaction, shipping and regasification.

The STEPS, and especially the ARC, result in looser oil and gas market balances in the years ahead. In the STEPS, some of the technological shifts already underway, notably electrification and greater deployment of renewables, are accelerated by the 2026 crisis. This results in no net growth in oil demand between 2025 and 2035, and gas demand growth that is around 40% lower than historical levels. In the ARC, accelerated efforts to reduce import dependence, diversify energy sources and improve efficiency lower oil demand by 5 mb/d

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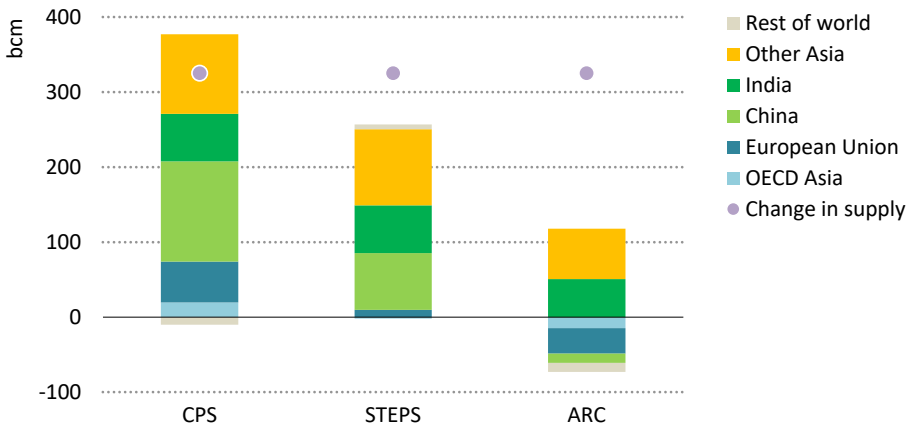
from its level in 2025 and keep gas demand largely flat. The result is a significant overhang of potential LNG supply (Figure 1.27). This overhang could provide insurance against additional interruptions to supply, for example if there were longer-term impediments to exporting LNG from the Gulf. In the absence of such additional disruptions, if all planned LNG projects came onstream in the ARC, prices would fall to the short-run marginal cost of supply.

Figure 1.27 ▷ Change in LNG imports by scenario, 2025-2035



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LNG supply growth runs ahead of demand in the STEPS and the ARC through to 2035, loosening market balances and leading to lower prices for importers

Notes: OECD = Organisation for Economic Co-operation and Development. Change in supply is the net change in available LNG export capacity, considering under-construction projects as of October 2026, net of anticipated retirements.

Rebound effects can be a powerful countervailing force, and persistently low commodity prices could draw in additional demand and help bring markets back to balance. However, structural changes in technology and the availability, or otherwise, of infrastructure could limit the extent to which lower prices stimulate demand. This is especially the case in gas markets. For example, a meaningful rebound in gas demand in the ARC due to lower prices could be held back in practice by more rapid deployment of lower marginal cost renewables, with batteries playing a greater role in providing short-term flexibility. Meanwhile, the upside for gas from coal-to-gas switching is capped on the one hand by the challenging economics of delivering LNG at prices that are competitive against imported coal, and on the other by coal remaining a preferred fallback option for security of supply.

Low prices can also store up risks for future market balances if they remain too low to attract the necessary investment in supply. This matters for oil and gas given the long lead times involved in developing new resources and the need to maintain supply: fields naturally decline due to depletion effects, falling at a rate of around 8-9% per year, and this rate is

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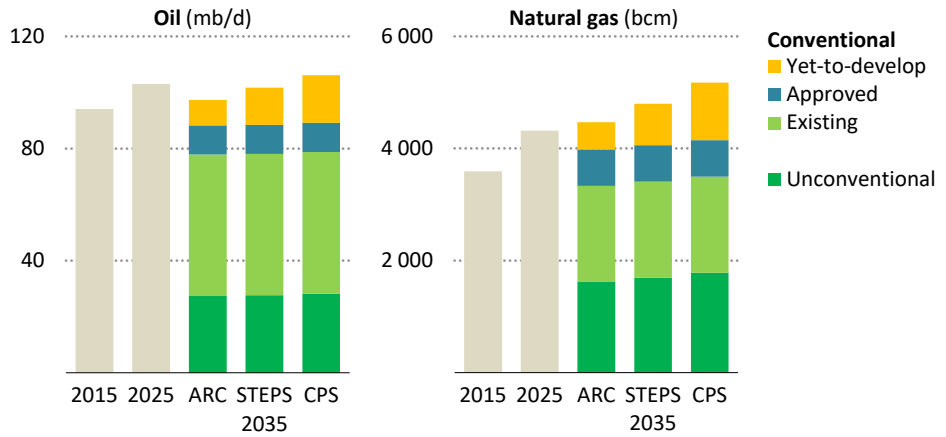
generally higher outside the Middle East. Consequently, nearly 90% of the USD 550 billion invested in upstream oil and gas each year over the past five years has resulted in simply offsetting production declines rather than meeting demand growth. In the ARC, around 9 mb/d of new oil projects and 500 bcm of new gas projects are required by 2035, even though demand is declining; this rises to 17 mb/d for oil and 1 000 bcm for gas in the CPS (Figure 1.28).

Figure 1.28 ▷ Oil and natural gas resources developed by scenario, 2015-2035



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Despite the potential for well-supplied oil and gas markets in the years ahead, ongoing investment in new supply is still required, even in cases in which demand is flat or declining

Notes: Existing projects include primary, secondary and enhanced oil recovery techniques and include extensions, such as infrastructure-led expansions. Approved projects are those that have reached final investment decision as of 2026 and are scheduled to start production from 2026 onwards. Yet-to-develop supply includes discovered and undiscovered resources that are yet to be approved for development. See Annex C for definitions of unconventional oil.

Overall, the price and supply projections for oil and gas in all scenarios apart from the CPS point to a period of comfortable market balances once the conflict in the Middle East is over. This could provide some relief to households and businesses that are tired of high fuel costs, and to many governments around the world grappling with the macroeconomic and fiscal consequences of those high costs. But this period of market easing has been pushed back once by geopolitics, and this could happen again. Fuel-importing countries may therefore still look to develop alternative energy sources closer to home, not least by supporting policies that favour electrification.

An abundance of clean technology?

Ample supply is already a feature of some parts of the clean energy economy, although the high level of concentration in clean technology manufacturing raises broader economic

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security issues, including those related to critical minerals, as discussed above in section 1.6. Manufacturing capacity has expanded much faster than deployment, most notably for solar PV and batteries. Current global manufacturing capacity for both technologies is sufficient to produce roughly twice the volumes deployed in 2025, contributing to intense competition and falling equipment prices (IEA, 2026b). Solar PV module prices fell by around 50% between 2023 and 2025, and battery pack prices by around 25%. China accounts for a large majority of global manufacturing capacity for both technologies, and a significant share of its surplus production is exported. Wind manufacturing is less clearly in surplus, while other technologies, particularly nuclear power, face quite different constraints, including limited project pipelines, specialised supply chains and financing, and long construction lead times.

However, readily available clean technologies do not necessarily lead to abundant low-cost electricity supply. Supplies of solar panels, batteries or wind turbines are only the starting point. They need to be financed, installed and connected to the grid, and the electricity they produce needs to be available when and where consumers need it. This is particularly important for solar PV and wind: plentiful generation can already push wholesale prices very low or even negative at certain times, but cheap electricity in the middle of the day is of limited value if demand comes later and there is insufficient storage, demand flexibility or transmission to shift it. Maximising the benefits that clean technologies offer electricity markets therefore depends increasingly on the wider power system.

When clean technologies are successfully integrated, they can lessen the exposure of electricity costs to swings in fuel prices. Wind, solar PV and nuclear power shift electricity systems towards upfront investment and away from recurring fuel expenditure; grids and storage add to capital requirements, but they enable greater use of this low-emissions generation. Systems therefore become more capital-intensive but less fuel-intensive, making their underlying costs more stable (see Chapter 7). In regulated electricity systems, these changes feed relatively directly into the average costs that ultimately need to be recovered. In liberalised wholesale markets, there is an additional effect: since wind and solar PV have very low short-run operating costs and come ahead of fossil fuel generation in the merit order, their expansion can reduce the number of hours in which natural gas- or coal-fired plants set wholesale electricity prices.

Experience in 2026 in Europe provides a useful example of the relationship between prices for natural gas and wholesale electricity. The 2026 energy crisis pushed European gas prices sharply higher: wholesale gas prices were close to 50% higher year-on-year in the first ten months of 2026. Because gas-fired plants continued to set wholesale electricity prices for a significant number of hours, the shock extended to electricity markets: average EU wholesale electricity prices increased by about 30% over the same period (indicating an elasticity of close to 0.7 to gas prices). The extent of exposure to a gas price shock therefore depends not simply on the amount of gas-fired electricity generation but on how often gas is the marginal source of generation and sets prices for the market as a whole.

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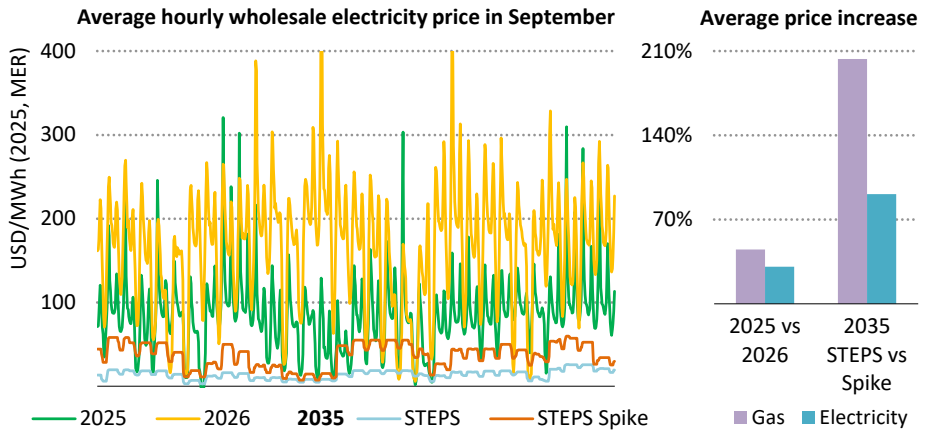
Increasing clean generation can weaken the ability of gas to set prices for the whole market in this way, especially where storage allows more renewable electricity to be used when it is most valuable. Australia provides a recent example. In its National Electricity Market, growing renewable generation and a rapid expansion of battery storage are reducing reliance on gas-fired generation, particularly during higher-priced periods. In the second quarter of 2026, grid-scale batteries more than tripled the amount of electricity shifted from periods of high daytime solar output into the evening peak, contributing to gas-fired generation falling 30% year-on-year to its lowest second-quarter level since 2003. Average wholesale electricity prices fell by almost half, with the lower and flatter price profile attributed to increased renewable output, battery discharge during peak periods and lower evening peak demand (AEMO, 2026). Battery storage is thus helping to convert abundant renewable generation in particular hours into electricity that can displace higher-cost generation across more of the day, reducing the influence of gas on wholesale prices.

These effects become increasingly important as clean electricity expands. In the STEPS, renewables provide half of global electricity generation by 2035, solar PV becomes the largest source of electricity and nuclear generation also expands. Battery storage grows rapidly alongside them from nearly 300 GW today to more than 2 100 GW by 2035. The result is not simply more low-emissions electricity but a power system that can make greater use of that electricity and is less exposed to fluctuations in fossil fuel markets.

Figure 1.29 ▷ Wholesale electricity and gas prices in Europe in the STEPS in 2025, 2026 and 2035



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Increasing shares of clean generation weaken the relationship between gas prices and wholesale electricity prices in Europe, providing more stability for consumers

Notes: 2025 and 2026 values are derived from ENTSO-E (2026). STEPS Spike = 2035 STEPS with 2026 average natural gas price.

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New WEO hourly modelling for Europe illustrates the effect. Today, natural gas sets the wholesale electricity price in around 45% of hours throughout the year. As renewables, nuclear power and storage capacity expand, this share steadily declines in the STEPS to 2035, and the link between gas and electricity prices consequently weakens. An assessment of a rise in the average gas price in 2035 to the average level seen in January to October 2026 concluded that such a rise would mean a 200% increase in the projected gas price in the STEPS in 2035, in turn raising average power system costs by just 5% and wholesale electricity prices by 90% in 2035 (Figure 1.29). The large amplification of fuel price shocks through wholesale electricity markets seen today is therefore substantially reduced.

Abundant clean technologies therefore need to be understood as a starting point rather than an end point for making energy more affordable. Low equipment costs can make it cheaper to expand electricity supply, but only if grids, storage and other sources of flexibility keep pace. Nor do changes in wholesale markets translate one-for-one into household bills. The recovery of long-lived investments, together with network costs, taxes, levies and subsidies, may mute or delay the effect on retail prices. The impacts may also be distributed unevenly, making tariff and market design important in determining who ultimately benefits. Greater clean technology abundance may not mean that electricity prices invariably fall as electricity systems become progressively less exposed to volatile international fuel prices and the shocks that accompany them.

1.8 How can the world maintain momentum on access to electricity and clean cooking?

Progress on access slowed for several years after the Covid-19 pandemic and the 2022 energy crisis. The latest IEA tracking points to an acceleration in access to electricity and clean cooking in 2025, but around 720 million people still live without electricity, and nearly 2 billion rely on polluting cooking methods. Sub-Saharan Africa is home to 90% and 50% of these populations, respectively.

The 2026 energy crisis threatens the renewed momentum seen in 2025. In many developing economies, the disruption to flows through the Strait of Hormuz has quickly fed through into higher prices for diesel, kerosene and liquefied petroleum gas (LPG), in some cases straining public utility finances. These higher prices hit low-income households the hardest, since they spend a larger share of their income on energy than wealthier counterparts.

The impact of the energy crisis extends beyond the energy sector. Higher fertiliser and transport costs are adding to food prices, raising food security concerns in import-dependent countries, while more expensive cooking fuels raise the cost of preparing meals. Data on how the crisis has affected access in 2026 remain limited, but past shocks show how quickly gains can be eroded: in 2022, the number of people without electricity increased worldwide for the first time in decades, and the spike in LPG prices following Russia's full-scale invasion of Ukraine slowed progress on clean cooking, with some households reverting temporarily to cooking with traditional biomass.

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Recent trends in clean cooking

Progress on clean cooking has recently gathered pace in sub-Saharan Africa, where the challenge is greatest. Nearly 12 million people in the region gained access to clean cooking in 2024, compared with around 4 million in 2010. Early data indicate that this momentum continued into 2025, which could set a record for the pace of progress. More than USD 2.2 billion was pledged to be delivered before 2030 at the 2024 Summit on Clean Cooking in Africa, and USD 740 million has since been deployed in projects ranging from infrastructure to stoves across 28 countries in sub-Saharan Africa. Population growth in sub-Saharan Africa has nevertheless outpaced these gains, and the number of people without access increased by around 14 million in 2024.

The 2026 crisis has created significant headwinds that threaten continued progress. Around 75% of the people gaining access to clean cooking worldwide in recent years have done so through LPG, and the Middle East is one of its largest exporters. LPG prices have risen by as much as 100% in some import-dependent markets since the onset of the crisis, and higher fuel costs risk slowing adoption among first-time users. They may also push households that recently switched to LPG to cut back on it or to use it alongside traditional fuels. The full impact is not yet visible in the data and will need to be monitored closely. The disruption has also underlined the value of diversified supply routes, adequate storage and a broader mix of clean cooking solutions, including electric cooking, bioethanol and biogas.

Recent trends in electricity access

Progress on electricity access has also picked up. More than 30 million people gained access to electricity in 2025, with the number of people without access falling to around 720 million. That compares with 16 million people gaining access in 2024 and an average of 68 million a year between 2010 and 2019. Sub-Saharan Africa accounted for around three-quarters of the improvement, with off-grid systems – notably solar home systems and mini-grids – helping expand electricity access in more remote areas. Record solar home system sales brought electricity to 9 million people in 2025, supported by falling technology costs, subsidies and consumer finance. Rising PV imports suggest rapid expansion of distributed and off-grid solar, although uptake appears skewed towards wealthier communities. Not all imported capacity is captured in installation statistics, leaving a sizeable tracking gap (Box 1.9).

Here too, the 2026 crisis is weighing on progress. Over the first nine months of the year, global diesel prices reached record levels. This raises the cost of running the generators that many households, businesses and public facilities rely on where grid supply is absent or unreliable. Utilities that depend on oil-fired generation face higher fuel bills, adding to their financial strains and to the risk of power shortages. Meanwhile, high debt, rising borrowing costs and tighter development budgets continue to constrain investment in grids and new connections. One side-effect of higher fuel costs has been to strengthen the economic case for solar-based solutions.

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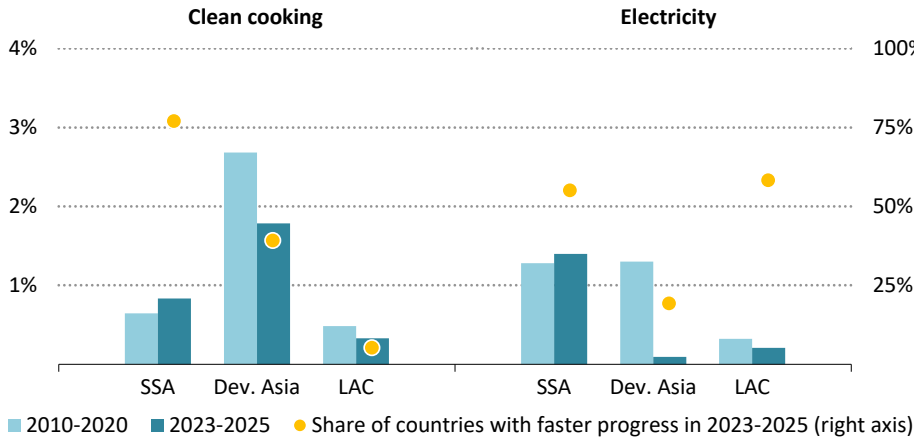
Domestic and international political attention to improving access to both electricity and clean cooking has risen in recent years. Access has become a regular and important item on the international agenda: it featured prominently under the last three Conferences of the Parties and G20 Presidencies, and it is increasingly reflected in the NDCs put forward by countries. Since 2023, more than 50 countries have made faster progress on electricity access than on average during the decade before the Covid-19 pandemic, and almost 60 have done so on clean cooking (Figure 1.30).

Figure 1.30 ▷ Average annual progress in clean cooking and electricity access, and share of countries with faster progress in 2023-2025 than in 2010-2020



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Energy access progress is accelerating in sub-Saharan Africa, with more than half of countries advancing faster between 2023 and 2025 than in the previous decade

Note: SSA = sub-Saharan Africa; Dev. Asia = developing Asia; LAC = Latin America and the Caribbean.

The outlook in the STEPS

Recent policy action is the main reason for improvements in access to clean cooking and electricity. IEA tracking shows that more than 120 new clean cooking policies or programmes have been introduced or announced across Africa since the 2024 Summit on Clean Cooking in Africa, and almost 90% of people without access to clean cooking now live in countries that have strengthened their policy frameworks. Nineteen African countries have also signalled their willingness to implement further clean cooking policies ahead of the second Summit. The picture is similarly positive for access to electricity. Around 90% of people who currently lack access live in countries with an electricity access target, and above 35 countries have adopted national energy compacts under Mission 300.

In the STEPS, this momentum translates into faster progress, but it still falls short of universal access by 2030 for both electricity and clean cooking. On average, 65 million people gain

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access to clean cooking each year to 2035. The number of people without clean cooking falls to around 1.6 billion in 2035 as faster progress in sub-Saharan Africa adds to continued gains in developing Asia. In sub-Saharan Africa, the number of people without access to clean cooking peaks before 2030 and declines to around 970 million by 2035. This would be a turning point after decades in which population growth outpaced progress. LPG continues to underpin most new access globally. Meanwhile, the number of people without access to electricity falls to around 550 million in 2035. Decentralised solutions provide one-quarter of new connections in sub-Saharan Africa by this date, but the region is still home to 95% of the people without electricity in 2035.

A key source of uncertainty is how long the current energy crisis will persist. The crisis continues to strain the public finances of fuel-importing countries and undermine affordability, particularly for clean cooking: progress in many countries relies heavily on imported LPG and is therefore vulnerable to a prolonged period of high prices.

What it would take to close the gap: the ACCESS

The Accelerating Clean Cooking and Electricity Services Scenario (ACCESS)[4] shows what is possible if countries replicate the fastest rates of progress achieved in comparable contexts until the energy access gap is closed. Universal access to electricity is reached by around 2035, with around 75 million people gaining access each year, compared with more than 30 million in 2025. Universal access to clean cooking is reached around 2040, with an average of 130 million people gaining access each year and most of the acceleration happening in sub-Saharan Africa (Figure 1.31).

Achieving this requires around USD 24 billion per year for electricity access and USD 4 billion for clean cooking. It also requires a shift in clean cooking investment towards sub-Saharan Africa, and electricity access investments must increase sixfold. Public and concessional capital plays a critical role in anchoring private investment, especially in less mature markets and lower-income communities. The second Summit on Clean Cooking in Africa in January 2027 provides a major opportunity to mobilise additional financial commitments.

Affordability is the other decisive factor. Success depends on measures that make access affordable for the poorest households. These measures could include well-targeted support, greater use of carbon finance to lower upfront and running costs, and reform of the import duties and taxes that raise the cost of clean cooking equipment and fuels.

By 2040, universal access adds around 370 TWh of electricity demand and 1.2 mb/d of LPG demand, and it brings an increase of 460 petajoules in the consumption of modern biomass, biogas and bioethanol. In aggregate, this represents around 6% of global final demand growth in the ACCESS.

[4] The Accelerating Clean Cooking and Electricity Services Scenario (ACCESS) charts a path to achieve universal access to clean cooking and electricity based on the best rates of progress achieved historically. The ACCESS prioritises cost-effective and proven measures to improve access, considering all relevant fuels and technologies, and the infrastructure, policies and financing needed to scale them up.

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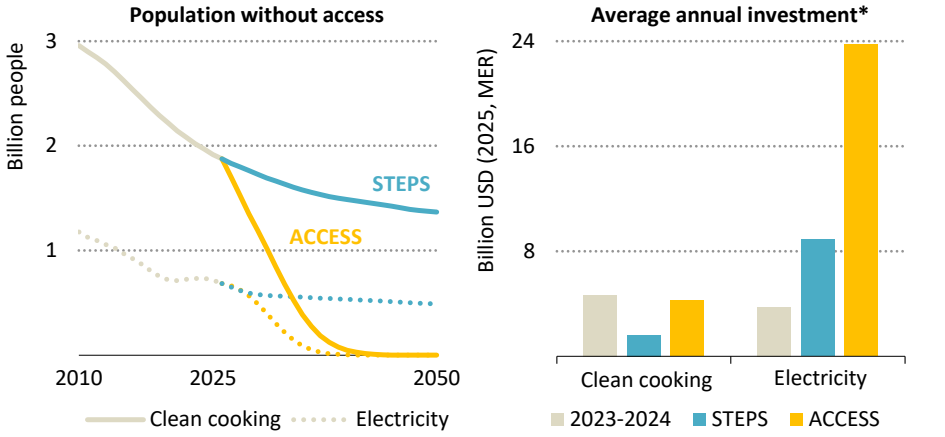
Figure 1.31 ▷ Population without access to electricity and clean cooking, and average annual investment by scenario, 2010-2050



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Universal access requires a sharp increase in investment in electricity access and a shift in clean cooking investment from Asia to sub-Saharan Africa

* Investment is averaged over 2025-2040 for clean cooking and 2025-2035 for electricity access.

Note: ACCESS = Accelerating Clean Cooking and Electricity Services Scenario.

Box 1.9 ▷ Where are Africa's solar imports going?

Trade data suggest that there have been around 60 GW of solar PV imports from China to Africa since 2020, but recorded solar PV capacity additions have totalled less than half of this figure over the same period. In 2025 alone, solar PV imports reached around 26 GW, while reported installations totalled approximately 10 GW (Figure 1.32).

The gap between imported and installed capacity amounts to around 35 GW over the past five years. There are a number of possible reasons for this mismatch. Equipment often remains in inventories for extended periods. When it is used, installations are often not fully accounted for in official statistics. Growing exports from some African countries raise questions about whether some of this equipment is being re-exported to other markets, or whether there are structural inconsistencies in trade and deployment statistics. In addition, around 15% of solar imports are cells rather than finished modules, some of which may supply Africa's emerging manufacturing industry. PV module production capacity was minimal in 2025, but Egypt and Ethiopia have since emerged as the leading producers; several other countries, notably Nigeria, have ambitious expansion plans.

Newly developed IEA tools combining satellite imagery and remote sensing provide fresh evidence that a significant share of imported solar PV is being deployed in utility-scale

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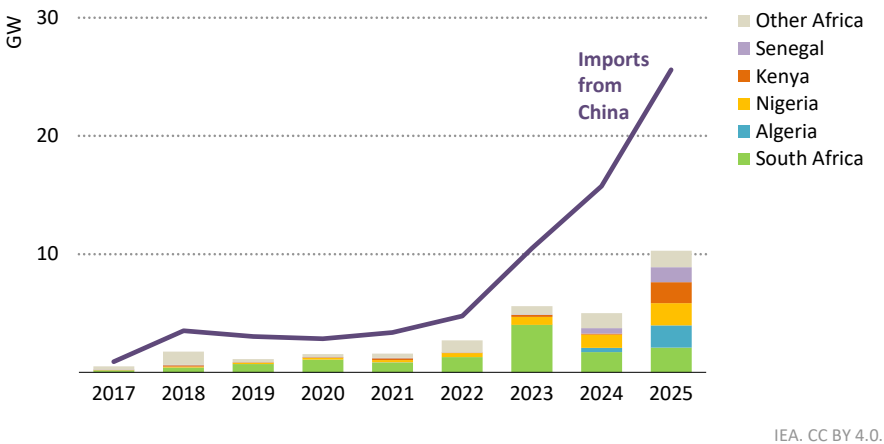
and distributed systems that are missing from official statistics. Across Africa, this analysis identified over 50% more utility-scale solar capacity than is officially recorded. Even after correcting for this undercount, however, the additional capacity detected from space is insufficient to account for imported volumes, leaving a gap of almost 30 GW.

Figure 1.32 ▷ Solar PV capacity additions and imports from China in Africa, 2017-2025



Solar PV imports from China have increased 28-fold since 2017, reaching 26 GW in 2025, but registered capacity additions are much smaller

Source: IEA analysis based on GACC (2026).

Distributed systems that cannot be reliably tracked through remote sensing may explain some of the difference, but they are unlikely to account for all of it. To shed light on this, the IEA conducted a detailed, city-level assessment of rooftop solar in Johannesburg – a city with some of the highest known levels of distributed solar. The analysis reveals a fivefold increase between 2020 and 2025, bringing estimated rooftop solar capacity to more than 400 megawatts, which is roughly 60% higher than the small-scale embedded generation capacity in official records. Even after this disparity is scaled up to cover other major cities in Africa, the installed base remains too small to explain the scale of imports in South Africa and other African countries.

Africa's exports of solar panels, which had been negligible until 2024, have also risen sharply, reaching almost 6 GW in 2025 – equivalent to around 22% of imported volumes. The United States accounted for about 70% of the value of these exports, with India accounting for most of the remainder. Preliminary 2026 data suggest that export volumes are continuing to rise sharply. These re-exports may well explain a further part of the gap between the import and installation of solar PV.

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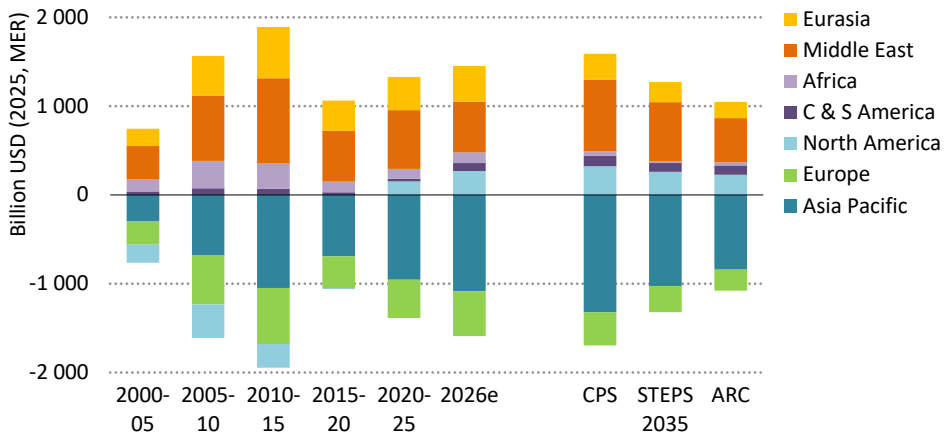
1.9 What's next for the world's oil and gas producers?

The surge in prices in 2026 as a result of the conflict in the Middle East has generated a major windfall for the oil and gas industry, with exporters set to receive an additional USD 700 billion from oil and gas sales in 2026 over and above the ten-year average (Figure 1.33). This increase in income has not been available to all – some Gulf exporters such as Iraq have seen their export revenues fall sharply – and it will not necessarily translate into a large increase in new oil and gas investment. Producers saw their income increase by 65% after the 2022 energy crisis, but investment increased by only around 30%, with the majority of the windfall going to shareholders and host governments or being used to pay down debt. In 2026, we estimate that upstream oil and gas investment will be around USD 550 billion, around 1% higher than in 2025, with increases in Africa, Asia Pacific, and Central and South America offset in large part by reductions in the Middle East. Moreover, the IEA Upstream Capital Cost Index is expected to move upwards by around 8% in 2026. This will limit increases in drilling activity, equipment purchases and new production capacity, and it will also raise the risk of overruns and delays for projects already under development; it will also lead to closer scrutiny of projects yet to be sanctioned.

Figure 1.33 ▷ Average annual value of net oil and gas trade by scenario, 2000-2035



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The value of oil and gas trade is set to exceed USD 1.5 trillion in 2026; it is still above this level in the CPS in 2035, but it drops to about USD 1 trillion in the ARC

In the longer term, oil and gas producers and prospects for upstream investment face uncertainty on many fronts. The first, and most immediate, concerns the duration of the 2026 energy crisis, the shape of the "new normal" for Middle East exports, and the impact of the crisis on policies, especially in fuel-importing countries. Our scenarios and cases take

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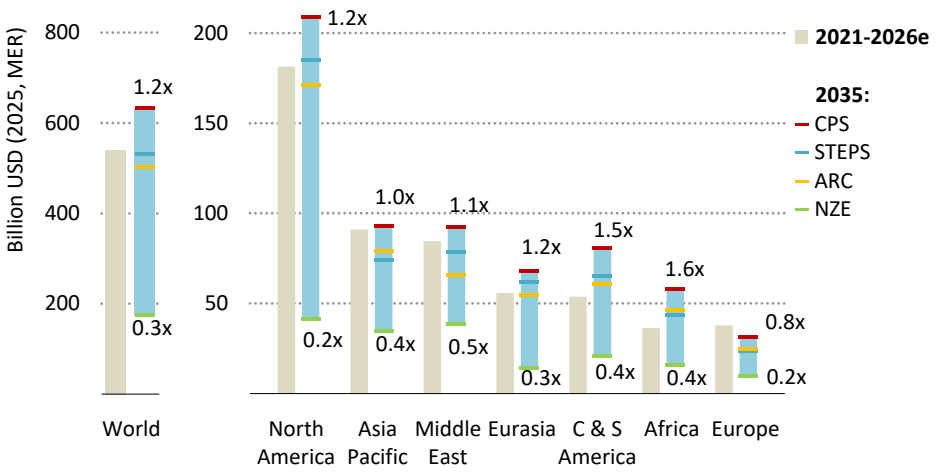
divergent views on the longer-term effects of the crisis: the CPS assumes that there are few long-term changes in policy preferences as a result of the conflict in the Middle East; the ARC assumes additional efforts by importers to limit imports, diversify fuel supplies and build buffers to provide protection and insurance against future security risks; the STEPS occupies the middle ground between the CPS and the ARC (Figure 1.34). Middle East producers have announced plans to develop 7 mb/d of new export pipeline capacity that bypasses the Strait of Hormuz and could carry nearly 30% of the volumes that they exported in 2025. The Low Hormuz Case (LHC) looks at the extent to which flows through the Strait could be cut over the next ten years (see the Spotlight).

Figure 1.34 ▷ Average annual upstream oil and gas investment by region and scenario, 2021-2035



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Upstream oil and gas investment grows by 25% in the CPS, is flat in the STEPS and in the ARC over the next decade, but shrinks by 60% in the NZE Scenario

The second uncertainty relates to the increased scope for higher production from countries that have historically faced restrictions. These countries include the United Arab Emirates, which left OPEC in May 2026 and plans to increase crude oil production capacity to 5 mb/d by 2027. In the STEPS, production in the United Arab Emirates rises to 5.8 mb/d in 2035 (1.4 mb/d higher than in the *WEO-2025* STEPS). These countries also include Venezuela, where production is set to increase by 0.1 mb/d, reaching 1.1 mb/d in 2026 as revised hydrocarbon laws and overall security improvements take root. Production rises to 1.5 mb/d in the STEPS in 2035 (0.9 mb/d more than in the *WEO-2025* STEPS) on the back of cumulative investment of around USD 70 billion over this period as operators refurbish existing facilities and develop new fields.

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The third source of uncertainty is the outlook for demand and prices. Oil demand in the STEPS levels off around 2030 and declines slowly to 102 mb/d in 2035, while in the CPS, demand rises steadily to around 106 mb/d in 2035. The higher level of demand in the CPS requires more costly sources of supply to come online, and this leads to materially higher prices: the 4% difference in oil demand between the CPS and the STEPS in 2035 results in a 13% difference in prices. From a company and financing perspective, a small shift from expectations of demand growth to a plateau or gradual decline can significantly affect investment decisions. Uncertainty over China looms large in this context since it accounted for about 30% of global imports of oil and gas between 2020 and 2025. In recent years, China has demonstrated significant flexibility during crisis periods, adjusting down its annual oil imports by about 10% in 2026 and its LNG imports by 20% in 2022 through a combination of stock withdrawals, fuel switching and other forms of demand response. However, the past may not be a good guide to the future. China therefore represents a crucial "swing factor" in global oil and gas demand projections.

The final uncertainty concerns the pace of energy transitions. In the very rapid clean energy transition modelled in the NZE Scenario, the scaling-up of clean energy technologies leads oil and gas demand to fall by an average of around 4% per year to 2035. The steepness of these falls means that no new long lead-time conventional oil and gas projects would be required in this scenario, while some existing supply would need to be shut in. While the current pace of structural change in the energy sector is a long way short of that modelled in the NZE Scenario, this illustrates how new oil and gas projects could face substantial commercial risks if transitions accelerate, placing sustained pressure on existing business models.

Whatever the outlook for demand, the industry can expect increasing scrutiny of emissions from its own operations. The production, processing and transport of oil and gas currently account for just under 15% of global energy-related greenhouse gas emissions. Already today, several importing countries are beginning to differentiate oil and gas imports by their emissions intensity. Producers that can demonstrate effective action to reduce emissions can credibly argue that their resources should be preferred over higher-emissions alternatives.

SPOTLIGHT

Can markets balance without flows through the Strait of Hormuz?

In a world in which free flows of oil and gas through the Strait of Hormuz are resumed, oil exports through the Strait recover to 20 mb/d in 2035 (similar to 2025 levels) in the STEPS, while the passage of LNG grows from 110 bcm to almost 200 bcm. In the Low Hormuz Case (LHC), we look at the extent to which this dependence could be cut over the next ten years.

For LNG, there are no feasible routes that bypass the Strait of Hormuz, so alternative supplies from elsewhere and demand responses are the only credible ways to reduce reliance on the Strait. There is around 70 bcm of LNG export capacity that is surplus to

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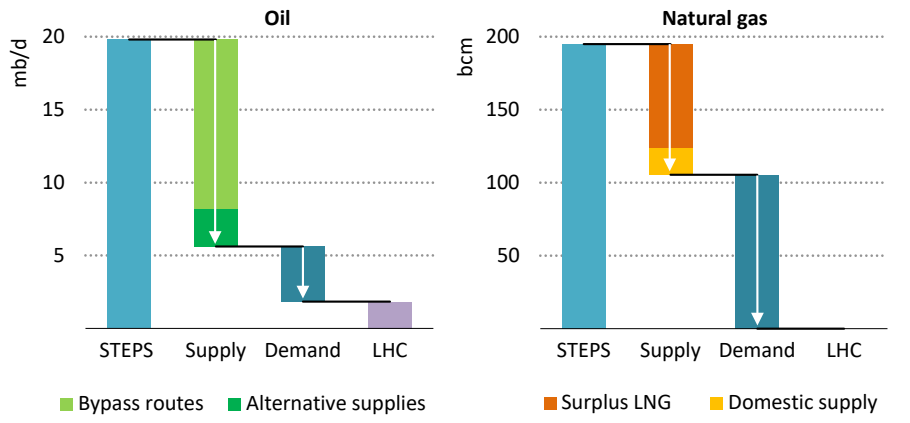
requirements in 2035 in the STEPS (see section 5.4.4). This surplus capacity could be called upon for alternative supplies. Increasing domestic production in importing regions above the levels in the STEPS, mainly in China and Europe, could avoid around 20 bcm, while demand response measures in importers could avoid 105 bcm. As a result, it would be theoretically possible in the LHC to bring LNG flows through the Strait of Hormuz to zero. This would, however, imply the stranding of all Qatari and UAE capacity, which is among the lowest cost capacity in the world.

For oil, there is currently around 8 mb/d of pipeline capacity that bypasses the Strait of Hormuz to serve export markets, and a further 7 mb/d that is under construction or proposed. Around 3 mb/d of this capacity is used in the STEPS in 2035, but if all new pipelines were to be completed and operated at their maximum effective capacity, this could increase bypass flows to around 15 mb/d in 2035. On this basis, most Saudi and UAE exports could avoid the Strait, along with around 60% of Iraq's exports. A concerted effort from producers outside the Strait of Hormuz to maximise domestic production by introducing more attractive upstream fiscal terms could yield a further 2 mb/d of additional supply to the market in the LHC in 2035. Additional demand response measures by importers (as modelled in the ARC) could cut oil demand by around 4 mb/d. Putting these elements together, the LHC sees flows through the Strait drop to less than 2 mb/d in 2035 (Figure 1.35).

Figure 1.35 ▷ Oil and natural gas flows through the Strait of Hormuz in the STEPS and the Low Hormuz Case, 2035



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The LHC manages to do without gas that comes through the Strait, but not without oil; most of the oil that is re-routed goes through pipelines vulnerable to disruption

Note: LHC = Low Hormuz Case.

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Building the new bypass capacity would require around USD 40 billion, while raising supply outside the Strait of Hormuz would require around USD 200 billion of additional cumulative upstream investment above STEPS levels between 2025 and 2035.

Achieving these reductions in oil and gas flows through the Strait of Hormuz would require a wide range of measures to be implemented in parallel, and many of these would be very challenging in practice unless the Strait is effectively closed for transit. If the Strait is at least partially open, there would be few reasons for Gulf producers not to use it, reducing the incentives and price signals for other producers to increase output. Under the same circumstances, there is also no guarantee that a reduction in international demand would feed through into a reduction in Gulf export flows through the Strait.

In the LHC, oil flows through the Strait of Hormuz are much lower than in the past, but nearly 15 mb/d of oil is still exported from the Middle East in 2035 (20% of global trade at that time), meaning that the Middle East remains a cornerstone of global oil supply. Many fuel security risks in the region would also remain: bypass pipelines are susceptible to physical attacks, as highlighted by drone attacks that temporarily shut down Saudi Arabia's 5.3 mb/d East-West pipeline in September 2026, and any exports to the Red Sea need to pass through the Bab el-Mandeb Strait, which is also a strategic chokepoint.

1.10 What does the wave of AI investment mean for the energy sector?

Surging data centre investment runs up against supply chain and grid bottlenecks

Electricity consumption by data centres globally grew by 17% in 2025, and data centre investments reached USD 565 billion. Driven by an AI boom, a further USD 4 trillion of investment spending associated with data centres is anticipated to be spent by 2030. Data centre capacity can be divided into two broad categories: conventional capacity for uses such as cloud storage and video streaming, and AI-optimised capacity that specialises in AI model training and use. In aggregate, the sector's electricity consumption doubles to 1 000 TWh by 2030 in the STEPS. Electricity consumption from AI-optimised data centre capacity drives around three-quarters of this growth.

The capital associated with data centres is being spent on constructing buildings that will house the servers, on acquiring chips and other electronics – and on energy sector equipment, including batteries, transformers, grids and gas turbines. The central input to the IEA's data centre demand model is the annual global shipment of servers – the core equipment in which the data centre's computations take place. These data suggest that the stock of accelerated servers – those servers that cater to AI workloads – has grown 18-fold since 2020 (Figure 1.36).

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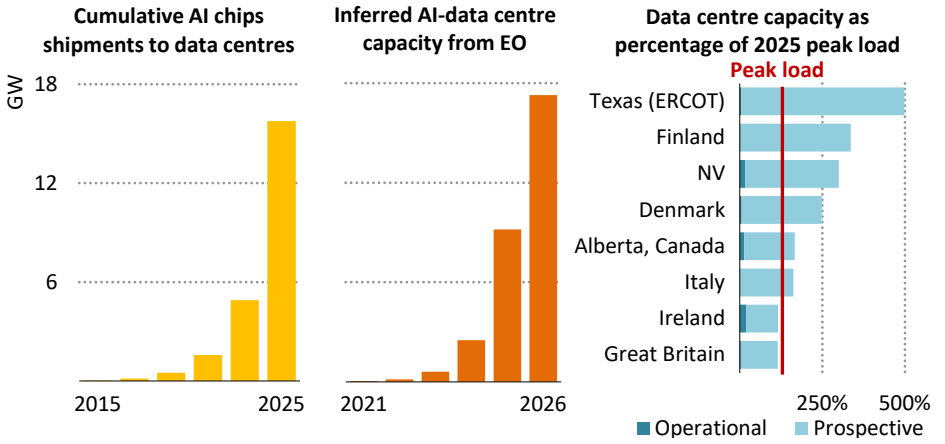
Figure 1.36 ▷ AI chips shipments, inferred AI data centre capacity, and data centre capacity as percentage of 2025 peak load



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AI chips shipments and the construction of AI data centres are surging, and the prospective capacity of data centres in key regions far exceeds today's peak loads

Notes: AI = artificial intelligence; EO = Earth observation; ERCOT = Electric Reliability Council of Texas; NV = Northern Virginia (Dominion Energy). Inferred AI data centre capacity is the potential capacity of 93 purpose-built AI data centres based on observed operational real estate. The 2026 value for inferred AI data centre capacity is as of September 2026.

Sources: IEA analysis based on Omdia (2026a); ESA (2026); Epoch AI (2026); IEA (2026c).

To improve the evidence base for this fast-moving sector, the IEA is using space-based imagery to track the buildout of 93 large "AI factories" – data centres that are purpose-built for AI. Our analysis has found rapid development of infrastructure, with the inferred potential capacity associated with such data centres growing 10-fold in just 24 months to reach 17 GW (Figure 1.36). Once these 93 AI data centres are completed, their combined capacity is set to be around 50 GW. Globally, data centres of all types have an aggregate capacity of 120 GW today, nearly 80% of which is in China, the European Union and the United States. Another 120 GW is built by the end of the decade in the STEPS, with over three-quarters of it intended to power AI-optimised servers.

The rapid growth of data centre capacity has been pushing electricity systems to their limits. Prospective capacity in jurisdictions such as Denmark, Finland, Northern Virginia and Texas is much larger than the current total peak loads that their grids can support. Not all this prospective capacity will be built. The surging requests for grid connections by data centre capacity have necessitated significant reforms in policies and regulation in key jurisdictions. These include rules that favour credible connection applications, bring-your-own-power arrangements and flexible data centre operations (IEA, 2026c). Despite reforms, grid connection queues are measured in years in several jurisdictions.

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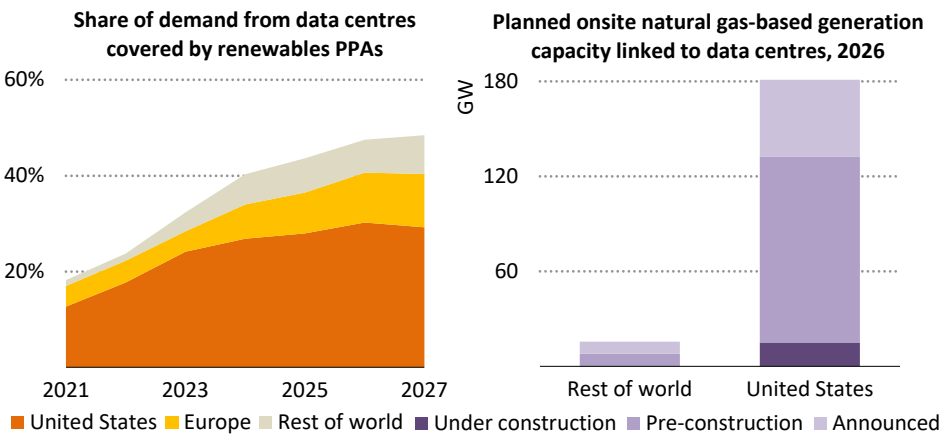
Grids are not the only constraint on new data centre capacity. Supply chains are struggling to keep pace with data centre demand and imposing a speed limit on how fast the data centre industry can grow. Bottlenecks particularly affect the supply of advanced chip packaging, memory chips and power equipment. They are expected to persist in the coming years, and they moderate our outlook for data centre electricity consumption.

Data centre companies are turning into energy makers

The technology industry has become the largest corporate procurer of renewables. Nearly half of global commercial data centre electricity demand is met by renewable power purchase agreements (Figure 1.37). The industry has also signed agreements with small modular reactor developers and geothermal-based electricity generation companies.

Figure 1.37 ▷ Data centre demand covered by renewables PPAs, and onsite gas generation capacity linked to data centres, August 2026



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Nearly half of commercial data centre electricity demand is backed by renewables PPAs; data centres are also driving a surge in orders for natural gas turbines in the United States

Note: PPAs = power purchase agreements.

Source: IEA analysis based on GEM (2026) and S&P Global (2026).

While contracts and agreements with renewable and nuclear generation companies help to develop low-emissions generation capacity, data centre companies still need to work out how to ensure the physical supply of electricity to their sites. Where grid connections are not immediately available, some data centre operators are planning onsite gas-fired generation capacity to power their operations. As of August 2026, around 180 GW of gas-fired capacity was planned in the United States to supply data centres, 11 GW in Canada and 4 GW in the rest of the world combined (Figure 1.37). However, the backlog in the supply of gas turbines means that most of this capacity is not expected to be operational until the 2030s.

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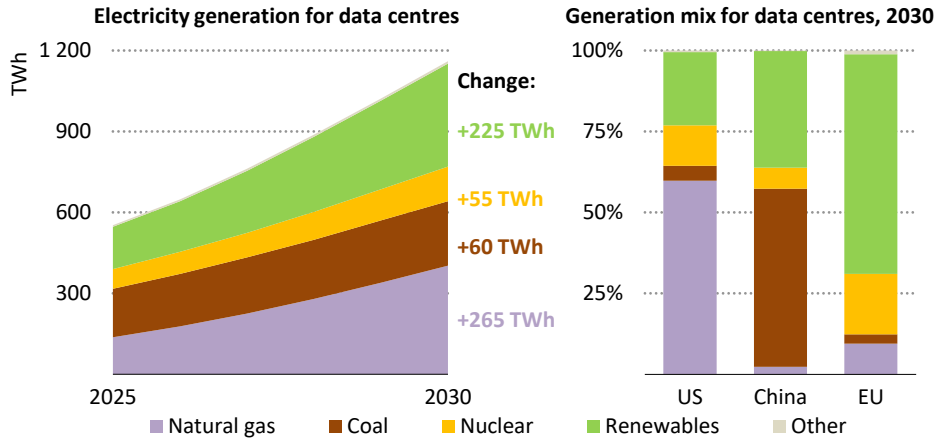
In aggregate, coal- and natural gas-fired generation currently accounts for around 60% of the physical supplies of electricity needed to meet global data centre demand. Natural gas and renewables generation meet most demand growth for data centres to 2030 globally. Local generation mixes, however, vary widely across regions (Figure 1.38). As a result of the growth in natural gas- and coal-fired power generation for data centres, emissions associated with this sector are on track to rise by 70% by 2030.

The data centre boom is also leading to a surge in demand for energy storage to manage spikes in electricity consumption and provide backup capacity. The IEA estimates that battery demand from data centres reaches around 25 GW by 2030. Other equipment such as solid-state transformers are also being developed to cater to data centre demand.

Figure 1.38 ▷ Global electricity generation for data centres in the STEPS, 2025-2030, and electricity generation mix for data centres in selected regions in the STEPS, 2030



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Renewables and natural gas account for 80% of the growth in global generation for data centres to 2030; there are diverse generation mixes in key markets

Note: US = United States; EU = European Union.

Public concerns over impacts on prices and the environment are growing

Data centre capacity growth is impacted not just by supply chain and grid constraints but also by local opposition to data centres. In the United States, sub-national authorities adopted nearly five times as many moratoria on data centre plans in the first seven months of 2026 as in the whole of 2025. These moratoria stem from concerns about planning, land use and the potential impact of data centres on local communities, electricity prices, the environment and water use (Box 1.10). Data centre construction has been similarly held up in other parts of the world. In September 2026, for example, Thailand paused 49 projects under construction and 117 awaiting approval while it developed rules covering electricity,

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water, siting, environmental safeguards and community impacts. The IEA's modelling of data centre demand factors in these developments.

Rising wholesale and retail electricity prices in many major economies, following the post-Covid-19 inflation spike and the global energy crises, have led to a particular focus on the likely impact of data centres on electricity prices. Connecting a large data centre to the grid can require investment in dedicated connection assets, wider network reinforcement and, in some systems, additional generation. Whether and when this affects the charges paid by other consumers depends on the spare capacity at the connection point, the size and operating profile of the facility and the flexibility it can offer when the network is constrained.

Analysis does not yet show a clear relationship between growth in data centre capacity and increases in electricity prices. Where a data centre requires additional network or generation investment, it can raise bills for other consumers if that cost is recovered from all users. Where it makes fuller use of capacity that already exists and pays its share of the cost, a data centre can spread fixed costs over increased consumption and ease pressure on bills. Regulators and policy makers around the world are considering innovative approaches to protect consumers from sharp electricity price rises while enabling data centres to contribute actively to grid flexibility, security, stability and sustainability (IEA, 2026c).

Box 1.10 ▷ Water use by data centres

Around 30% of existing and planned global data centre capacity is located in areas with high water stress. Water use by data centres[5] has come under increasing scrutiny: concerns about water are one of the main reasons for data centre moratoria.

Analysis shows that nearly 40% of data centre water use is associated with electricity generation, another one-quarter with the direct cooling needs of data centres, and the remainder with semiconductor and microchip manufacturing and primary energy supply. In all, water use associated with data centres totalled 885 billion litres in 2025 (Figure 1.39). Of this, 240 billion litres was directly used within data centres – equivalent to half a cup of water per day for every internet user in the world. However, this water consumption is concentrated in a few countries and regions as data centres are highly clustered.

Within a data centre, all electricity consumed by information technology (IT) equipment is eventually converted into heat that has to be extracted from the servers and the IT racks to the outside environment. In conventional data centres, air is usually used to evacuate heat, but AI-optimised servers generate significantly more heat than conventional servers, and liquid cooling is being increasingly deployed to carry away their heat.

[5] Water use could refer to water withdrawal, most of which is returned to the local water system, or to water consumption, the share of withdrawals that is not returned, most often because of evaporation. In this section, water use refers to consumption.

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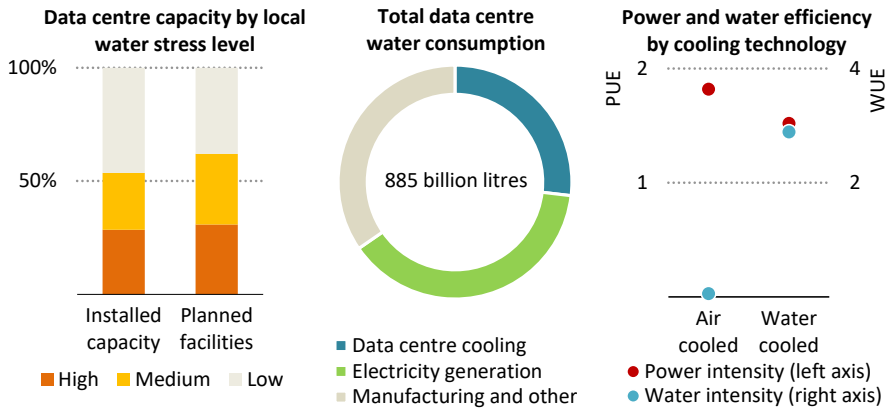
Air-cooled systems, such as dry coolers, rely on ambient air to extract the heat from the coolant. While they limit the water footprint, these systems are typically less energy efficient, particularly in hot climates. Water-cooled systems rely either on the high heat capacity of water or on evaporation. They are more energy efficient than air-cooled systems, but they also use much more water. As a result, there is a trade-off in data centres between water use and energy efficiency. The use of efficiency metrics such as Power Usage Effectiveness (PUE) and Water Usage Effectiveness (WUE) should take this trade-off into account.

Figure 1.39 ▷ Data centre capacity by current water stress level, 2026, total data centre water consumption, 2025, and power and water efficiency by data centre cooling technology



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More and more data centre facilities are set to be located in areas that are already water-stressed, making the choice of cooling technology crucial

Notes: PUE = Power Usage Effectiveness; WUE = Water Usage Effectiveness. Water stress is the ratio of total water demand to available renewable water supply, weighted by population: low <20%, medium 20-60%, high >60%. "Other" water use refers to primary fuel extraction and manufacturing. PUE is defined as the ratio of total facility to IT electricity consumption and is dimensionless (kWh/kWh). WUE is the ratio of facility water consumption to IT electricity consumption and is expressed in L/kWh. PUE and WUE values for the two cooling configurations are illustrative simulations for chillers in midsize facilities as defined in Shehabi et al. (2024) and do not represent all data centre cooling technologies.

Sources: IEA analysis based on Omdia (2026b); IEA (2025); WRI (2023); Shehabi et al. (2024).

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Setting the scene

Context and design

SUMMARY

- The disruption to oil and gas supply from the conflict in the Middle East is the largest energy security threat that the world has ever faced. At its peak, global oil supply fell by 16 million barrels per day (mb/d) and gas supply by 320 million cubic metres per day. The near closure of the Strait of Hormuz also cut off supplies of fertilisers, aluminium, sulphur and helium, heightening risks for industry and food security.
- The largest impacts on oil consumers were felt through shortages of petrochemical feedstocks and liquefied petroleum gas for cooking, and through higher prices, especially for diesel and jet fuel. Global oil demand is expected to fall by around 2.7 mb/d in 2026, its first annual decline since 2020, while natural gas demand is set to decrease by around 1.5%, or 65 billion cubic metres.
- Price rises for crude oil were more contained than the scale of the disruption might suggest, thanks to initially well-stocked inventories, the largest ever IEA co-ordinated stock release, bypass routes for Gulf exporters that avoided the Strait, and additional supplies from non-Gulf producers. The global energy system is also very different from that which faced previous supply shocks. Decades of efficiency gains, electrification and fuel switching have reduced reliance on oil, while more diverse sources of supply and increasingly flexible global markets have added resilience.
- Alongside short-term actions, the 2026 energy crisis has prompted many countries to review long-term policy priorities and strategies to guard against future shocks. Against a highly uncertain backdrop, the *World Energy Outlook* looks at different ways in which these responses could play out. All these potential energy futures use the same gross domestic product and population assumptions; none is a forecast.
- The **Current Policies Scenario** has the greatest degree of continuity with pre-conflict settings, as it considers only those policies and measures that are firmly embedded in legislation. The **Stated Policies Scenario** also reflects policies that have been proposed but not yet implemented and thus incorporates some policy reactions to the crisis.
- More policy responses could come, especially if the conflict persists. With this in mind, we consider an **Additional Response Case**, which takes preliminary reactions from different countries and asks what could happen if these turn into actionable policy proposals and are implemented. A **Low Hormuz Case** further examines possible moves to minimise reliance on the future passage of fuels through the Strait.
- These scenarios neither assume that long-term climate goals are met nor achieve pre-determined outcomes. By contrast, the **Net Zero Emissions by 2050 Scenario** maps out an updated global pathway for the energy sector to achieve the specific goal of net zero carbon dioxide emissions by 2050.

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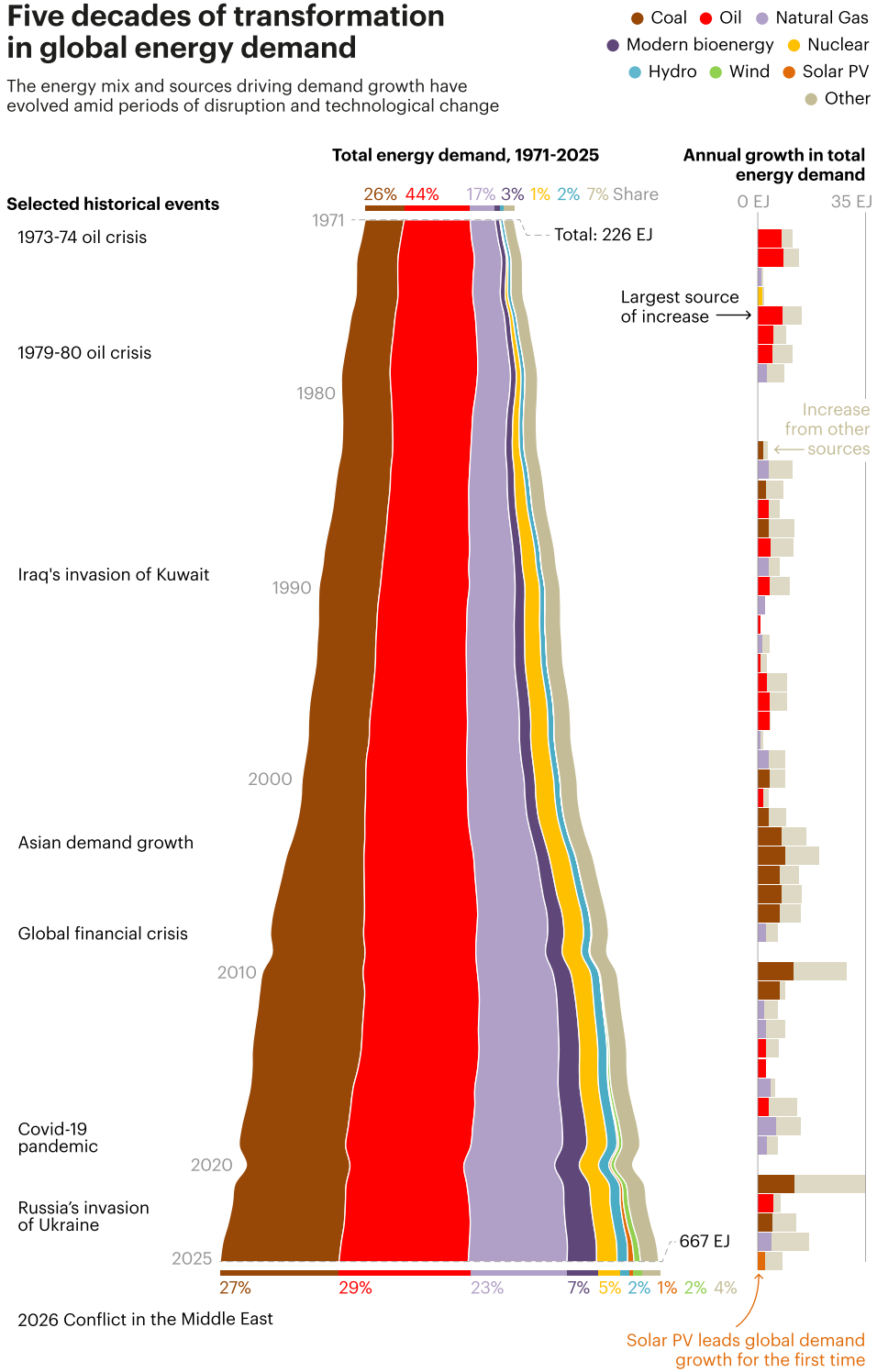
Five decades of transformation in global energy demand

The energy mix and sources driving demand growth have evolved amid periods of disruption and technological change



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2.1 Introduction

The *World Energy Outlook 2025* (*WEO-2025*) opened with the observation that "pressing threats and longer-term hazards are elevating energy to a core issue of economic and national security." Energy security has long been defined by the International Energy Agency (IEA) as the uninterrupted availability of energy sources at affordable prices, and last year's *Outlook* highlighted that:

> *"[Decision makers] … need to consider a diverse set of vulnerability indicators across the energy system, including for example: the share of oil and gas transiting through maritime chokepoints such as the Strait of Hormuz; the increase in variable supply and peak demand for electricity; market balances and supply concentration of critical minerals; and energy security risks arising from extreme weather events that are exacerbated by continued high levels of energy-related emissions."*

Risks associated with the Strait of Hormuz have been a consistent theme of IEA analysis and a central part of the IEA's emergency response planning. The 2026 energy crisis and price spikes caused by the interruption of flows through the Strait have brought home the extent to which the energy system, and the broader global economy, depend on a 40-kilometre-wide waterway. Tackling this longstanding vulnerability has now become a priority both for Gulf producers and for fuel-importing countries around the world.

Over the past year, many parts of the world have also experienced exceptional periods of extreme weather, including record-breaking heatwaves in Europe, which contributed to outbreaks of wildfires, and major floods in southern Africa, China, Nepal and other parts of Asia. These events are occurring in a climate system that is, on average, 1.4-1.5 °C warmer than in pre-industrial times. This warming has increased their likelihood. Meanwhile, annual emissions from the energy sector remain at record levels, despite the growing deployment of a range of low-emissions technologies.

These pressing concerns sit alongside other urgent issues facing the world's energy decision makers, including high levels of energy poverty in a world in which 720 million people lack access to electricity and around 2 billion are without clean cooking fuels; major technological changes such as the rise of artificial intelligence (AI); rapid growth in electricity demand and emerging risks to electricity security; significant energy investment needs and cost pressures; and strains and dependencies in energy-related supply chains.

Considerable uncertainty remains about how the current crisis will play out, and governments may well reach different conclusions on how to respond to the wide-ranging and difficult challenges that they face. This is why this *Outlook* includes multiple scenarios, which examine a range of future trajectories for the energy sector. This chapter sets the scene for the *WEO* by exploring the immediate contours of the crisis and how it is prompting countries to review longer-term policy priorities and investment strategies. It then introduces the *WEO* scenarios and discusses the inputs and assumptions that underpin them.

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2.2 Context for the *World Energy Outlook 2026*

2.2.1 Energy trends prior to the conflict in the Middle East

Prior to the outbreak of hostilities in the Middle East at the end of February 2026, demand for all major fuels and technologies had been rising, showing the world's continued strong thirst for energy. Overall, global energy demand increased by 1.2% (8 exajoules) in 2025, just below the average for the previous decade and lower than the increase of over 2% in 2024. This slower pace of demand growth compared with 2024 reflects more rapid improvements in energy intensity amid similar rates of global economic growth.

For the first time on record, solar photovoltaics (PV) not only contributed the majority of growth in global power generation in 2025, but they also met a larger share of the growth in overall energy demand than any other source (Figure 2.1). Solar PV accounted for over half of a record 1 100 gigawatts (GW) of new installed capacity in the power sector, and in doing so, it met almost 30% of overall energy demand growth, ahead of oil (20%) and natural gas (17%). China remained by far the largest market for solar, adding nearly 400 GW of installed capacity, though the rate at which deployment increased actually fell year-on-year. Other significant contributions to the rise in global deployment came from the European Union, India and the United States. Utility-scale solar projects were increasingly accompanied by battery storage, which was the second fastest-growing power technology. Battery capacity additions rose by around 55% in 2025 to reach around 115 GW. The 2025 increase in solar PV generation, 600 terawatt-hours (TWh), was the third-largest ever achieved by any source in a single year.

Generation from wind power in 2025 increased by around 8%, held back by poor wind conditions in some major markets – notably in Europe, where output fell by 1%. Generation from hydropower remained at about the same level as in 2024. Nuclear generation grew by 1%, boosted by reactor restarts in Japan, the strong performance of plants in France, and new units that began operations in several countries. The share of power generated from low-emissions sources – renewables and nuclear – reached a record high of 42% in 2025.

Global demand for electricity grew by around 3% in 2025. While this was in line with the average over the last decade, electricity demand grew well over twice as fast as energy demand, underlining that the world has entered the Age of Electricity. Growth in electricity demand in 2025 came principally from a wide range of end-uses in buildings, notably space cooling, and from industry. Demand from electric vehicles (EVs) and data centres grew rapidly, although these uses still represent – for the moment – a relatively small share of overall electricity demand. Electric car sales grew by 20% globally to exceed 20 million in 2025, which means that one-quarter of all new cars sold were electric. In China, the world's largest electric car market, growth in electric car sales slowed, but EVs still accounted for nearly 55% of all car sales. Strong growth in Europe boosted the share of EVs in new car sales to 28%. Sales of EVs in Southeast Asia more than doubled to nearly 20% of the total new car market, led by Indonesia, Thailand and Viet Nam.

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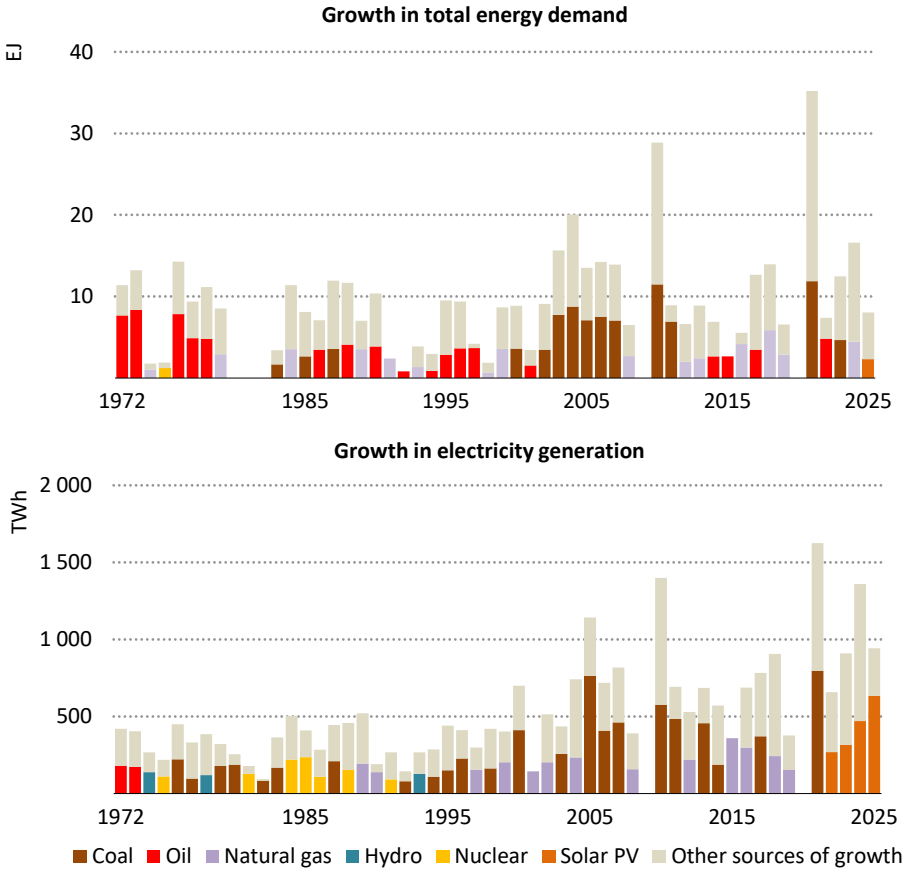
Figure 2.1 ▷ **Growth in total energy demand and electricity generation, and the source that met the largest share of growth, 1972-2025**



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In 2025, for the first time, a renewable energy technology – solar PV – met both the largest share of total energy demand growth and the largest share of electricity generation growth

Notes: EJ = exajoule; TWh = terawatt-hour; PV = photovoltaics. No data shown for years with no growth in total energy demand or electricity generation, net of the energy source contributing the largest share of growth.

The general trends towards low-emissions power and electrification vary widely by country. The share of electricity in final energy consumption has risen fastest in China, growing from 21% in 2015 to 32% in 2025. This indicator has barely moved in the European Union over the same period. It stood at 24% in 2025, though the generation mix continued to shift as the combined share of solar PV and wind in the European Union reached 30%, overtaking that of fossil fuels for the first time. The overall trend towards low-emissions generation,

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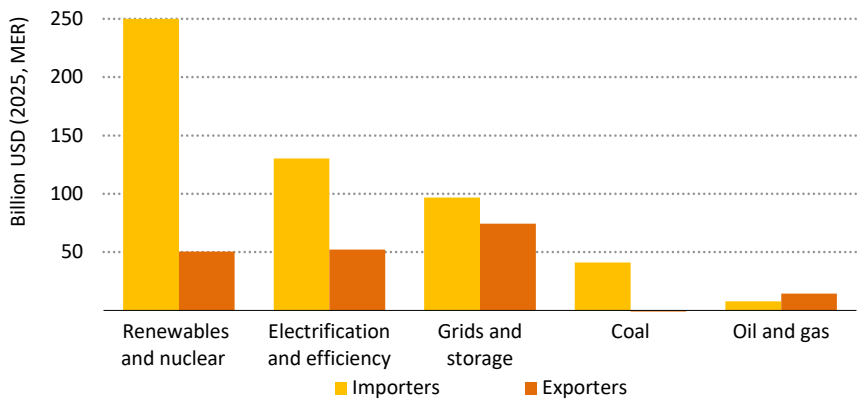
electrification and efficiency has accelerated since the global energy crisis in 2021-2023, especially among energy-importing countries (Box 2.1).

Box 2.1 ▷ The 2021-2023 energy crisis and energy investment flows

The energy crisis in 2021-2023 – which began in the wake of the Covid-19 pandemic and accelerated after Russia's full-scale invasion of Ukraine in February 2022 – was characterised by a significant rise in energy prices. Natural gas prices, in particular, rose steeply, with knock-on effects for electricity prices in many markets. One of the many changes brought about by this crisis was a major reorientation of capital flows to the energy sector. Our tracking of these flows in the *World Energy Investment 2026* report (IEA, 2026a) indicates that annual investments by energy-importing countries in low-emissions power, grids, storage, electrification and efficiency have increased by nearly USD 480 billion since 2022 (Figure 2.2). Global investment in these categories now accounts for nearly 65% of total energy spending, up from over 55% in 2021. Spending on coal supply has also increased, notably among oil- and gas-importing countries in Asia. The common denominator is that all these investments reduce reliance on imported fuels. This shift in investment flows suggests that, for net energy importers, energy security concerns are a major driver of investment in domestically produced sources of energy, including low-emissions and efficient technologies, and in electrification.

Figure 2.2 ▷ Change in average annual energy investment for net energy importers and exporters, 2017-2021 vs 2022-2026



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Energy investment in domestically available resources by energy-importing regions rose significantly after the 2021-2023 energy crisis

Notes: MER = market exchange rate. Importers include China, India, Japan, Korea, Southeast Asia, Other Asia and Europe. Exporters include Australia, New Zealand, Africa, Eurasia, Central and South America, the Middle East and North America.

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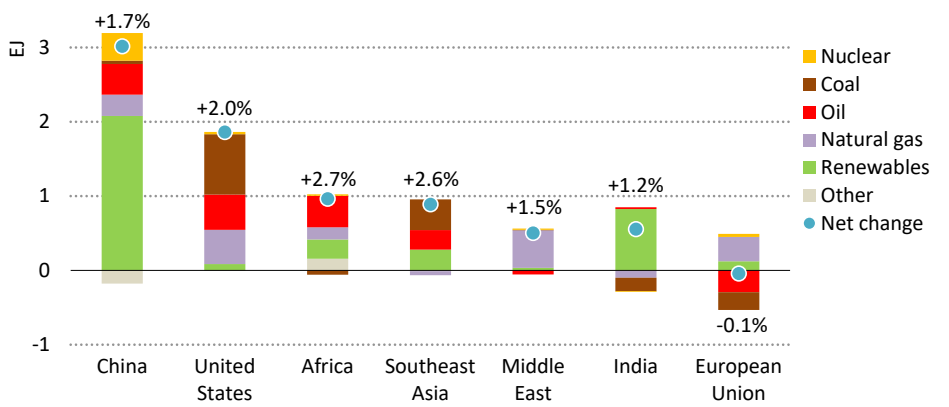
Oil market trends in 2025 were characterised by a large and persistent supply surplus. This was reflected in substantial stock builds of almost 500 million barrels, or 1.3 million barrels per day (mb/d), and downward pressure on prices, which were in the low USD 60s per barrel by the end of the year. Global demand grew by 1 mb/d, in line with IEA forecasts. In recent years, petrochemical feedstocks and fuels for aviation and shipping have played increasing roles as sources of growth in demand for oil. Road transport oil demand rose in 2025, but it is likely to fall in future years as a result of electrification and efficiency gains. Almost half of oil demand growth came from emerging market and developing economies in Asia, led by China. On the supply side, Saudi Arabia led the rise in supply from the Organization of the Petroleum Exporting Countries (OPEC) and allies (OPEC+) following the unwinding of production cuts, while non-OPEC+ supply growth was dominated by the Americas, with increases from Argentina, Brazil, Canada, Guyana and the United States.

Market conditions for natural gas also eased over the course of 2025 as global liquefied natural gas (LNG) supply started to increase, notably from the United States. Demand for natural gas rose by 1%, or 40 billion cubic metres (bcm); it increased in Europe due to a relatively cold winter, as well as in the gas-rich Middle East and United States, but it was subdued in Asia. More sluggish demand growth did not deter project developers from approving almost 100 bcm of annualised LNG export capacity globally, around 90% of which is in the United States. The scale of these approvals reflects expectations for continued long-term growth in LNG demand, particularly in Europe, where efforts are being made to replace remaining Russian gas imports, and in Asia, where LNG is expected to support growing demand for electricity and industrial energy.

Figure 2.3 ▷ Change in energy demand by selected region and source, 2025



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Demand growth in the United States was boosted by strong electricity consumption from data centres, while China's growth rate was well below the levels of recent years

Note: Other includes traditional use of biomass and non-renewable waste.

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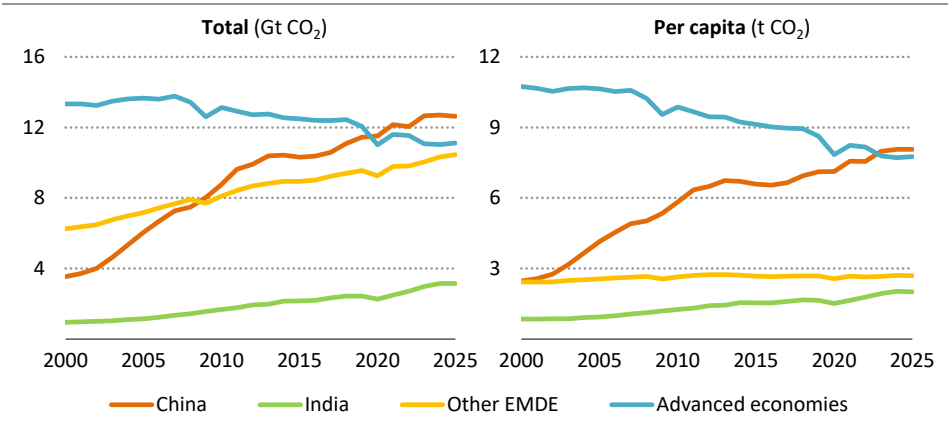
Global coal demand grew by 0.3% in 2025, an increase of around 20 million tonnes (Figure 2.3). Demand rose by 4% in Southeast Asia and 9% in North America, the only major markets in which coal consumption saw robust growth. In China, a significant increase in low-emissions generation and slower demand growth from the power sector held coal consumption flat. Since China consumes over a third more coal than the rest of the world put together, its flat year-on-year demand had a strong influence on the global picture. In India, the second-biggest global coal consumer, an early and strong monsoon season depressed electricity demand and boosted hydropower output. In the United States, where coal demand has decreased by an average of 6% annually over the past 15 years, consumption rose by 10% in response to higher natural gas prices and a policy push to slow down the retirement of coal plants.

Demand for key energy minerals such as lithium, nickel, cobalt and graphite, and rare earths continued to grow strongly in 2025, driven primarily by their increasing use in energy technologies, including batteries for EVs and energy storage; in electricity infrastructure such as grids, wind turbines and solar PV; and in permanent magnets for high-performance applications. Demand for these key minerals and rare earths has grown at close to 10% annually on average in recent years, and their prices picked up in 2025 following some downward pressure in 2023-2024. The prices of base metals also rose in 2025, driven by tightening supply conditions, particularly in copper and aluminium markets. Critical mineral supply remains highly concentrated, especially for refined materials, for which most of the supply growth has come from the current top producer – Indonesia for nickel and China for most other key energy minerals.

Figure 2.4 ▷ Total and per capita energy-related CO_2 emissions by selected region, 2000-2025



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China and India had declining or flat emissions in 2025; emissions from other emerging market and developing economies continued to grow

Note: Gt = gigatonne; CO_2 = carbon dioxide; t = tonne; EMDE = emerging market and developing economies.

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Energy-related carbon dioxide (CO_2) emissions rose by around 0.5% in 2025, with the rate of growth slowing from 1.4% in 2024. Emissions from China fell due to its growing use of renewables, structural shifts away from energy-intensive industry and overall slower energy demand growth (Figure 2.4). India's energy-related CO_2 emissions were flat, largely due to greater use of renewables and lower coal consumption. A cold winter and higher demand for coal and natural gas pushed up emissions in advanced economies by 0.7%, while emissions from emerging market and developing economies rose by 0.2%. It was the first time since the 1990s that emissions growth from advanced economies outpaced that from emerging market and developing economies.

2.2.2 The 2026 energy crisis in historical perspective

The 2020s have been an extraordinarily turbulent period for oil and gas markets, with the disruptive effects of the Covid-19 pandemic followed immediately by the energy crisis of 2021-2023, which was marked by Russia's full-scale invasion of Ukraine in 2022. Conflict in the Middle East has been a significant risk factor for energy markets over this period, for example with the Houthi attacks on shipping in the Red Sea in 2023-2025. However, the fighting that began with US and Israeli strikes on Iran at the end of February 2026 took this to a new level when Iran acted to restrict transit through the Strait of Hormuz.

Prior to the start of the conflict, oil exports through the Strait of Hormuz were around 20 mb/d on average, consisting of some 15 mb/d of crude oil and around 5 mb/d of oil products, accounting between them for some 20% of globally traded oil. The near closure of the Strait of Hormuz has rightly been seen as highly damaging because it did not just interrupt a key export flow but also negated one of the traditional safety nets for oil markets – the spare capacity held by major Gulf producers. Some 320 million cubic metres per day (mcm/d) of natural gas supplies (20% of the world's LNG trade in 2025) also relied on the Strait of Hormuz, together with other commodities, including fertilisers, aluminium, helium and sulphur.

Oil volumes transiting the Strait of Hormuz collapsed from 20 mb/d to an average of around 3 mb/d during March, April and May 2026 (Figure 2.5). Saudi Arabia and the United Arab Emirates were able to redirect some of their oil exports to alternative routes, notably the East-West pipeline to Yanbu on the Red Sea and the pipeline route to Fujairah. The conclusion of the Memorandum of Understanding between Iran and the United States led to a significant uptick in traffic through the Strait of Hormuz in June, but this fell back after the resumption of hostilities in early July. The subsequent rise of ship-to-ship transfers and transit under US protection led to another upswing in exports through the Strait of Hormuz in September and October, heavily weighted towards crude oil rather than oil products. Meanwhile, Saudi Arabia's exports via the Red Sea have been periodically affected since July by threats to transit through the Bab el-Mandeb Strait and by attacks on energy infrastructure, including the East-West pipeline.

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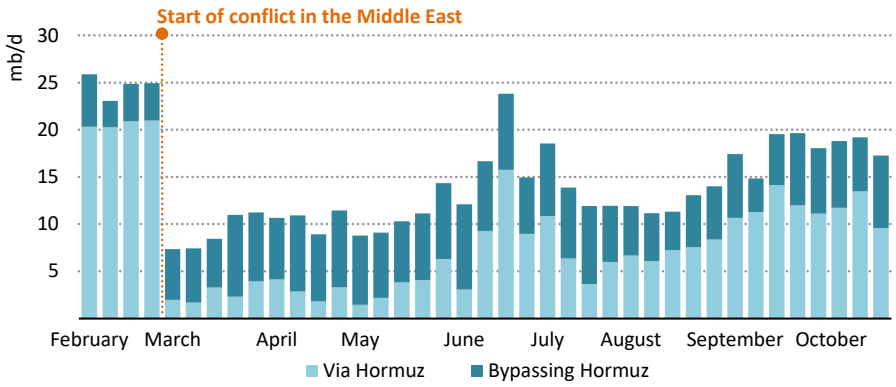
Figure 2.5 ▷ Weekly average oil exports from Gulf producers, February-October 2026



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After falling precipitously in March, oil exports from Gulf producers have oscillated between periods of recovery and decline, responding to changes in the security situation

Notes: mb/d = million barrels per day. Includes Saudi Arabia, Iraq, United Arab Emirates (UAE), Iran, Kuwait, Qatar, Bahrain and the Neutral Zone. Hormuz bypass includes Saudi Red Sea ports, UAE's Habshan-Fujairah pipeline, Iraq via Türkiye and Syria, and Iran's Jask Oil Terminal. October data provisional.

Source: IEA analysis based on Kpler (2026).

The effects of the Middle East conflict on LNG exports from the Gulf were more dramatic because LNG, unlike oil, has no alternative routes to international markets. Around 110 bcm of gas passed through the Strait of Hormuz in 2025: most of it came from Qatar, but some originated in the United Arab Emirates. Confirmed transits of LNG carriers picked up in mid-2026 and reached around 15 in September, but this was still far below the around 90 transits recorded in February. Gas infrastructure across the region has suffered damage, including from Iranian attacks on the huge Ras Laffan facility in Qatar, which removed more than 17 bcm/year of production capacity. Restoring this capacity will take an estimated three years.

How does the 2026 energy crisis compare with previous shocks?

The world has seen many disruptions to oil supply since the first oil shock of 1973, but the 2026 crisis has been the largest (Figure 2.6). At the peak of the disruption, global oil supply fell by 16.1 mb/d compared with pre-conflict levels, dwarfing previous major outages both in absolute volumes and as a share of the total market. The 2026 crisis has also been especially large for natural gas: the drop in supply as a result of the collapse in LNG flows from the Gulf was 318 mcm/d, around 20% higher than the peak supply loss seen in 2022 after Russia's full-scale invasion of Ukraine.

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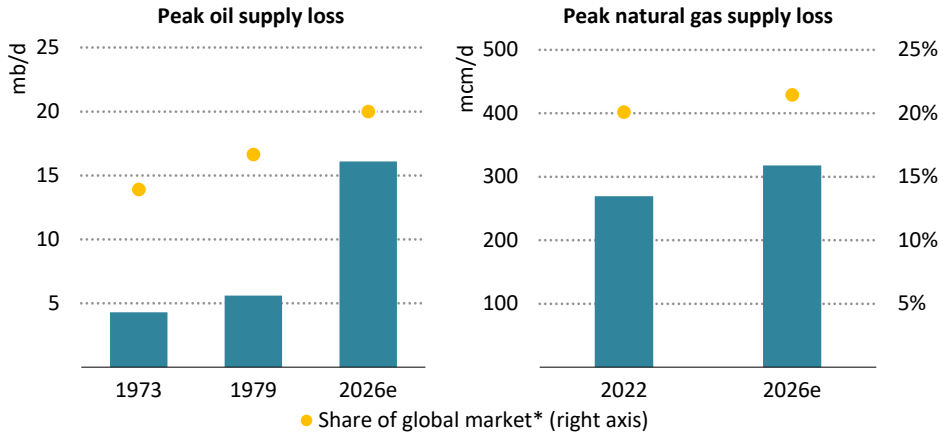
Figure 2.6 ▷ Historical comparison of oil and natural gas market disruptions



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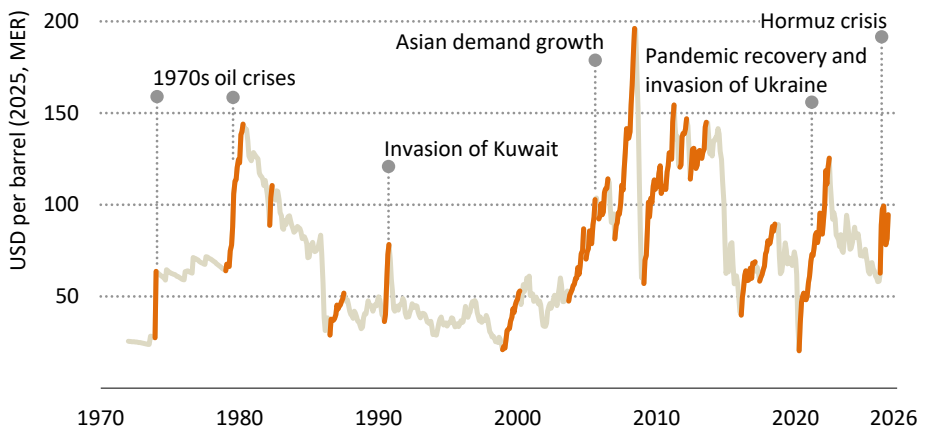
Oil supply losses from the March 2026 near closure of the Strait of Hormuz dwarf those from the two next-largest disruptions in modern history

Notes: mcm/d = million cubic metres per day; 2026e = estimated values for 2026. Peak supply loss refers to the maximum reduction in oil or natural gas supply during each crisis relative to average flows in the preceding month. *Share of global crude oil and oil products trade for oil; share of global LNG trade for natural gas.

Figure 2.7 ▷ WTI real price of crude oil and selected major oil price shocks, 1972-2026



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Record supply losses have not so far translated into record prices for crude, thanks to ample market buffers, but these buffers are depleting and the 2026 crisis is still not resolved

Note: WTI = West Texas Intermediate.

Source: IEA analysis based on US EIA (2026).

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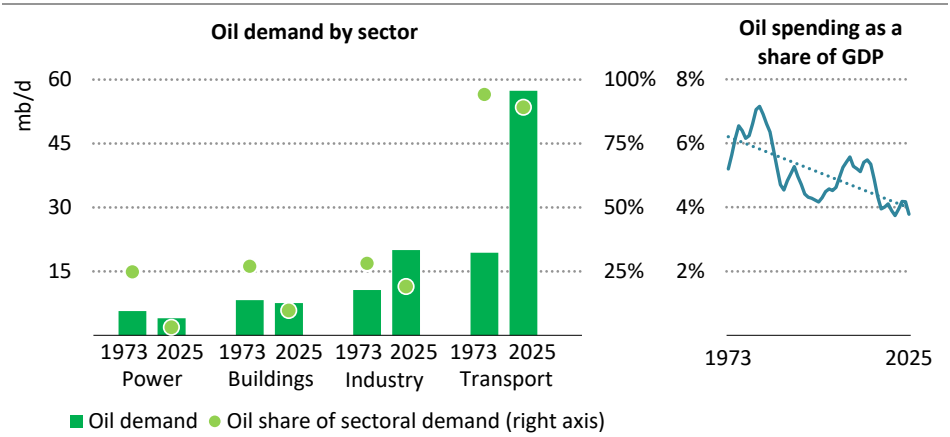
The size of the supply disruption does not automatically translate across to prices. A variety of supply- and demand-side factors have caused more dramatic increases in crude prices over the years than those seen so far in 2026 (Figure 2.7), while the spike in natural gas prices in 2022 was many times higher than witnessed to date in 2026. The market reactions in each case were shaped by specific circumstances. For example (as discussed in Chapter 1), the initial price impacts of the current crisis were cushioned because the world went into it on the back of an extended surplus of supply over demand in the case of oil, and at the start of a large expansion in LNG supply from North America in the case of gas. Price spikes in 2026 have nevertheless been significant, particularly for oil products such as diesel, which hit record levels – well above USD 200/barrel – in Europe and in the United States in September.

Broad structural factors also affect how disruptions play out. Oil and gas markets have changed significantly since the 1970s, in large part because of policy, consumer and investor responses to periods of supply shortfalls and market tightness. Below we trace some of these longer-term shifts, as – alongside the immediate circumstances – they provide essential context for understanding how events unfolded in 2026.

Structural changes in oil markets since the 1970s

A key structural consequence of the 1970s oil shocks was to loosen the relationship between oil demand and global economic output. Countries set about diversifying their energy systems away from oil (Box 2.2), and its use in power and buildings declined dramatically. However, oil's grip over transport remains strong: oil still accounts today for nearly 90% of energy use in transport, and demand is much higher than in the 1970s (Figure 2.8). There were around 250 million cars on the road in 1975, and there are around 1.4 billion today.

Figure 2.8 ▷ Oil demand by sector, 1973 and 2025, and oil spending as a share of GDP, 1973-2025



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Since the 1970s, all sectors have become less reliant on oil, though the fuel maintains a central role in transport

Note: GDP = gross domestic product.

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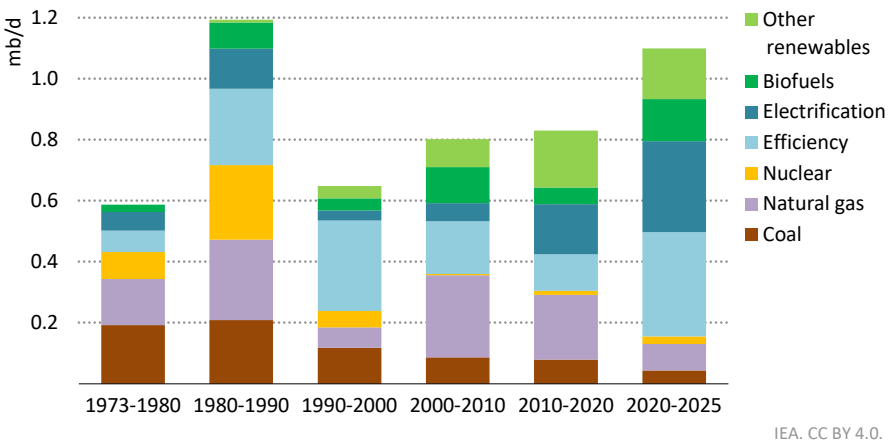
Box 2.2 ▷ How policies and technology have changed the game

An important structural change over the decades since the 1970s concerns the cost-competitiveness of technologies that allow for substitution away from oil and gas or that otherwise allow for more diversified supply. Much of this was policy-driven, at least initially, as governments sought to tackle the vulnerabilities revealed by successive shocks. The rise of nuclear and various renewable technologies, including biofuels, falls into this category, along with the wider adoption of efficiency standards and EVs. So does the development of new upstream technologies that have brought into play new resources such as deep offshore fields and shale.

Oil market balances are shaped not just by the barrels that are produced and consumed, but also by the barrels that never need to be consumed. Oil demand has grown at around 1 mb/d per year on average over the last decade. However, around the same amount each year has been avoided over the same period by efficiency gains, electrification and the deployment of other alternative fuels and technologies. Since 1973, substitution away from oil has displaced around 44 mb/d of oil demand (Figure 2.9).

Figure 2.9 ▷ Oil demand displaced by other fuels, efficiency gains and electrification



Efficiency, electrification and fuel switching across the energy system have displaced around 44 mb/d of oil demand since the 1970s

Policy responses to today's crisis can call upon a much wider array of cost-competitive alternatives to oil and gas than in the 1970s. Moreover, in many countries, the push to bring new technologies into the mix, for example by accelerating the electrification of transport, aligns well with energy transition and emissions reduction goals, which have risen dramatically in importance and prominence in the decades since the 1970s. But the policy landscape remains complex, especially in a fragmented international environment.

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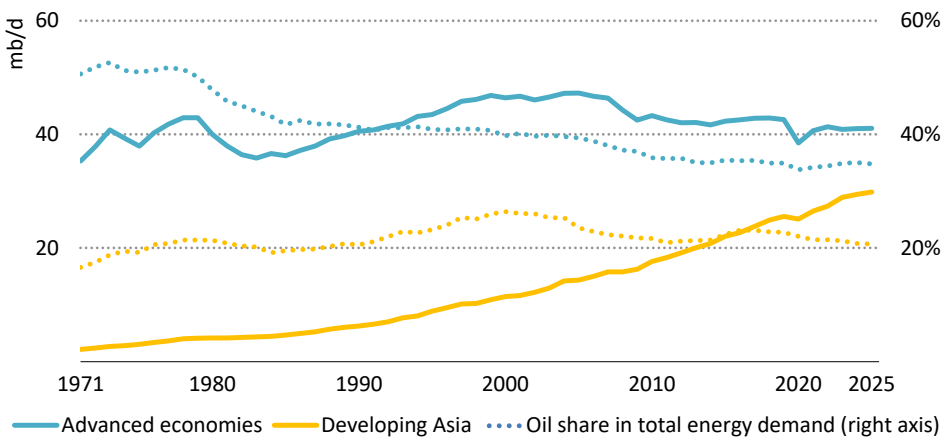
In practice, policy makers need to address multiple challenges simultaneously, including those arising from traditional risks to fuel security, emerging strains in the electricity sector, highly concentrated clean energy supply chains, ensuring the resilience of energy infrastructure to natural hazards and malicious attacks, and widespread sensitivity about affordability.

The geography of oil use has also changed markedly, with a big shift away from the advanced economies, where oil consumption is back around the levels seen in the mid-1970s, to emerging market and developing economies, where demand for oil has grown rapidly in recent decades (Figure 2.10). Developing countries in Asia have seen rapid oil consumption growth, and they have been particularly affected by the 2026 crisis through disruptions to refining and petrochemical production, higher prices and supply shortfalls for transport and cooking fuels. However, their overall reliance on oil to meet energy demand remains far below the level in advanced economies.

Figure 2.10 ▷ Oil demand and oil share in total energy demand, advanced economies and developing Asia, 1971-2025



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The centre of gravity for oil demand has shifted to Asia whose economies are now also key markets for Middle East exports, underscoring their vulnerability in the 2026 crisis

There have also been major shifts on the supply side. Back in 1973, the share of OPEC member countries in global oil production was around 50%. By 2025, it was around a third and was set to decline further with the announced exit of the United Arab Emirates. Over this period, global oil supply increased by 75%, including the addition of price-responsive tranches of supply, notably US shale, that can adapt quite quickly to changing market conditions. The creation of the IEA in 1974 also put in place a credible mechanism for a

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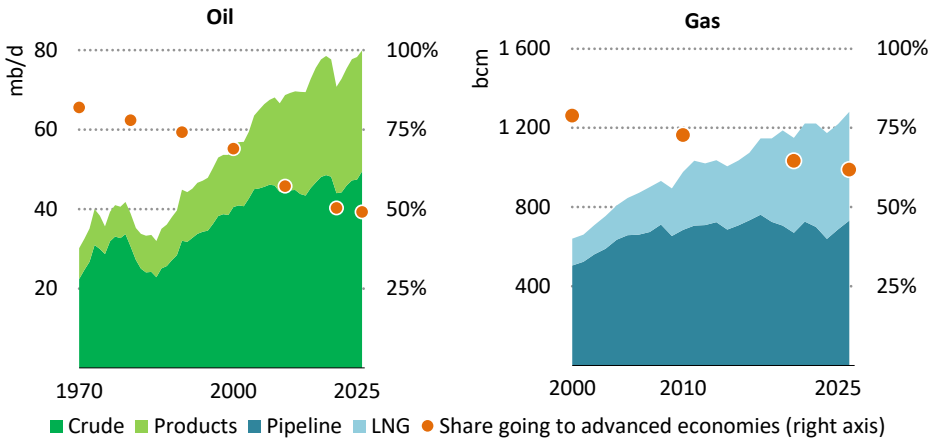
collective response by IEA members to oil supply disruptions via the release of emergency stocks and other co-ordinated actions.

Global oil supply remains geographically concentrated. The top three producing countries accounted for 43% of output in 2025, down only slightly from 45% in the early 1970s, while the top ten producers make up almost 75% of today's production, down from 80%. However, whereas oil supply growth in the early 1970s was led by Saudi Arabia, with the Soviet Union also making a major contribution, today's additional supply increasingly comes from the Americas – notably Argentina, Brazil, Canada, Guyana and the United States, with Venezuela now offering growth potential as well. Increased exports from the Atlantic Basin have been an important stabilising factor in 2026.

Figure 2.11 ▷ Gross oil and gas trade by type and share going to advanced economies, 1970-2025



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Oil products and LNG have become increasingly important in global energy trade, while the share going to advanced economies has declined

Notes: bcm = billion cubic metres; LNG = liquefied natural gas. Crude includes crude oil, condensates and other refinery feedstocks. Gross oil trade is the sum of crude and oil product imports by country; crude traded internationally may subsequently be refined and traded again as oil products.

Another change in oil markets that proved very significant in 2026 was the rise of trade in oil products (Figure 2.11). In the 1970s, international oil trade was largely in crude, with the major importers – mainly advanced economies – refining most of the oil products that they consumed. Today, oil products are much more widely traded, and the geography of refining has shifted. China, the Middle East and emerging market and developing economies in Asia have emerged as key refining hubs over the past few decades, collectively accounting for more than 40% of crude oil intake by refineries in 2025, up from 10% in the early 1970s. Whereas oil supply disruptions from the Middle East in the 1970s-1990s overwhelmingly

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affected crude supply, the current crisis has led to the loss of significant diesel, jet fuel, naphtha and liquefied petroleum gas (LPG) exports from the Gulf as well as crude oil exports. This loss of oil product exports has done much to shape the effects of the crisis.

In terms of pricing, the oil shocks of the 1970s had sharp and long-lasting implications because they were not just episodes of extreme imbalances between supply and demand: they stemmed primarily from action to move the whole mechanism of oil price formation onto a different footing. Before 1973, oil prices were set administratively by the major oil companies. After 1973, prices were still largely set administratively, but they were increasingly determined by the major producing countries, co-ordinated by OPEC. The result was a sustained tripling of prices. Although there are still many possible outcomes to the 2026 crisis, there are very few grounds to imagine a similarly dramatic upward reset in long-term oil prices.

It was only after the 1979 oil shock, when the Iranian revolution disrupted supply, and prices more than doubled again, that the system of official prices broke down and oil started to become a globally traded commodity, with myriad differentiations based on crude availability and quality, refining, logistics, storage and product prices. This proved to be an important shift amid the strains of 2026, with prices and price differentials providing granular guidance on where the supply constraints were most acute.

Natural gas has a much shorter history of major disruptions

Until recently, natural gas markets were much less prone to the sort of large-scale disruptions that oil has seen. The main point of tension was the gas supply and transit relationship between Russia and Ukraine, which resulted in temporary reductions in Russian export flows in 2006 and 2009. There were also supply interruptions in North Africa, notably from Libya to Italy in 2011. However, the effects of these disruptions were concentrated in specific markets.

The cut to Russian pipeline deliveries to Europe in 2022 following Russia's full-scale invasion of Ukraine prompted the first major global gas supply shock. European countries needed to find replacement volumes quickly and turned to international LNG markets, which by then had become much larger and more flexible with the shale revolution and the rise of US exports. LNG markets provided a lifeline for Europe, but also a transmission mechanism for the shock to the rest of the world amid intense competition for available cargoes. A similar mechanism was in play in 2026, although the market shock was mitigated somewhat by the continued expansion of export facilities in North America.

2.2.3 Impacts of the 2026 energy crisis

Energy

The energy impacts of the crisis have been asymmetric across fuels, geographies and types of consumers. They have also varied over time, as underscored by the oil price trajectories in different parts of the world (Figure 2.12). There was an initial price shock as buyers and

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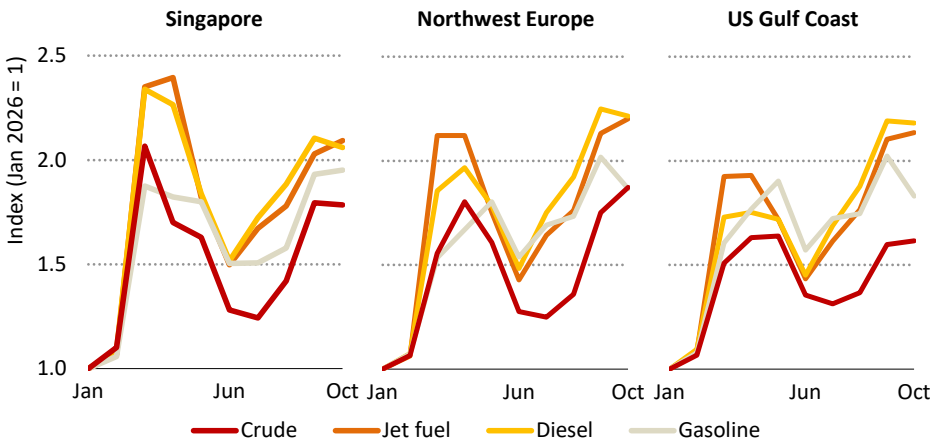
trade flows adjusted to the scale of the disruption. This was followed by an easing around mid-2026, as various stabilising elements came into play. On the supply side, these included releases from inventories, notably the IEA co-ordinated stock release of 400 million barrels, together with increased production and exports from suppliers in the Atlantic Basin and the use of alternative routes for Gulf exports. On the demand side, the key stabilising element was the dramatic reduction in China's crude imports (see Chapter 1, section 1.3). Hopes for a political resolution also picked up after the United States-Iran Memorandum of Understanding in June 2026.

Figure 2.12 ▷ Selected spot prices for crude and oil products, January-October 2026



The crisis has pushed up crude and oil product prices across regions, with particularly sharp increases in middle distillates

Notes: US = United States. Crude prices are Dubai for Singapore, North Sea Dated for Northwest Europe and WTI for the US Gulf Coast.

Source: IEA analysis based on data from Argus Media Group (2026). All rights reserved (full disclaimer on copyright page).

However, even though oil exports via the Strait of Hormuz in September were near their highest levels since February, price markers rose sharply in the third quarter of 2026 as inventories continued to be depleted and as energy infrastructure, shipping and export routes via the Red Sea faced renewed threats. Crude oil prices levelled off and then fell back in early November as Gulf crude exports continued to recover, but market strains remained acute for middle distillates, led by diesel, for which the effect of missing supplies from the Middle East was compounded by a collapse in exports from Russia following Ukrainian strikes on Russian refineries and other oil infrastructure.

Natural gas prices have followed a similar trajectory. An initial spike gave way to a calmer period in mid-2026, thanks largely to growth in LNG supply from outside the Gulf, and then

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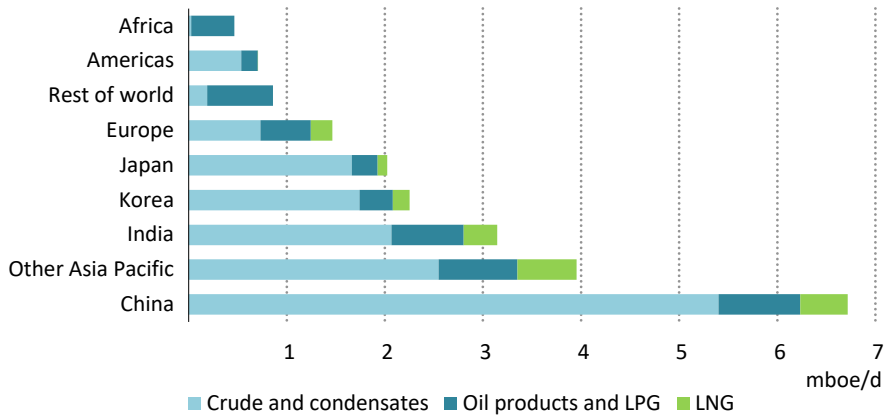
a steady tightening began in the third quarter as the Northern Hemisphere approached the winter heating season.

Outside the Middle East, the countries that felt the disruption directly were mostly in the Asia Pacific region, the destination for about 80% of oil and oil products transiting the Strait in 2025 as well as almost 90% of the LNG (Figure 2.13). This did not mean that other countries were immune. Market tensions and price impacts were transmitted quickly as competition for available crude, oil products and LNG cargoes picked up, prices rose and demand was squeezed. Emerging market and developing economies reliant on fuel imports but lacking inventories and the means to compete for supplies were among the worst affected, notably those – including small island states – where diesel is widely used for power generation. The latest IEA Oil Market Report, from November 2026, now expects world oil demand to decline by around 2.7 mb/d in 2026 – its first annual decrease since 2020 (IEA, 2026b).

Figure 2.13 ▷ Destinations of Middle East oil and LNG exports, 2025



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Asia received most Middle East exports in 2025, but the effects of the 2026 energy crisis were felt across many importing regions

Notes: mboe/d = million barrels of oil equivalent per day; LPG = liquefied petroleum gas. Rest of world includes bunkers.

Sources: IEA analysis based on data from ICIS (2026); Kpler (2026).

The largest initial impacts on oil consumers were felt among petrochemical producers, notably in Asia, who curtailed operating rates as feedstock supply dried up, and among households that rely on LPG as a cooking fuel. Some 3.5 billion people in emerging market and developing economies use LPG as their primary cooking fuel, and sharply higher prices and reduced availability put it beyond the reach of many of them. As markets tightened for middle distillates, the effects spread through road freight, airlines, and industrial, mining and agricultural consumers.

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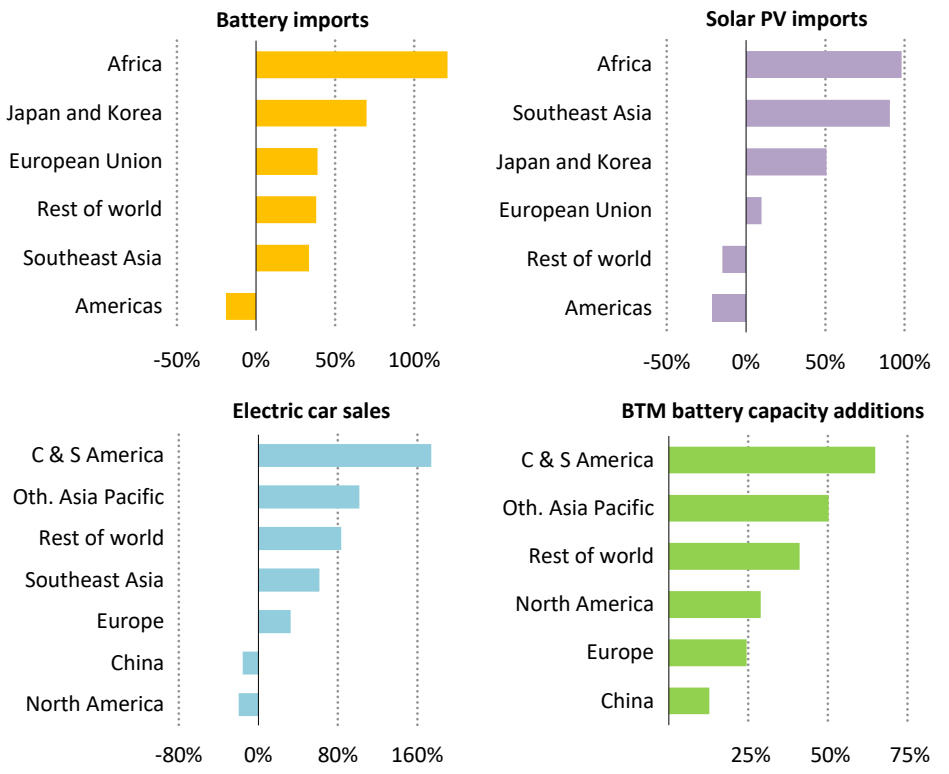
The size of the disruption to LNG pales by comparison with the missing volumes of oil, but the market impacts were nonetheless significant, curbing demand among gas-intensive industries and leading to some switching away from gas in the power sector, especially in Asia. Global gas demand is expected to fall by around 1.5% (or 65 bcm) in 2026, the third annual decline this decade following decreases in 2020 and 2022. Tight gas markets offered some near-term support for global coal use, which looks set to rise in 2026.

Figure 2.14 ▷ Selected energy technology trends, March-June 2026 versus March-June 2025



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Early evidence suggests that tighter fuel markets and higher oil and gas prices are accelerating solar PV, battery and EV adoption in many countries

Notes: C & S America = Central and South America; Oth. Asia Pacific = Other Asia Pacific. BTM = behind-the-meter. Battery imports cover lithium-ion batteries (HS code 850760); solar PV imports cover modules and cells (HS codes 854143 and 854142); data are based on values of imports from China in USD.

Sources: IEA analysis based on data from Global Trade Tracker (2026); JD Power (2026); ACEA (2026); CPCA (2026); Benchmark Mineral Intelligence (2026).

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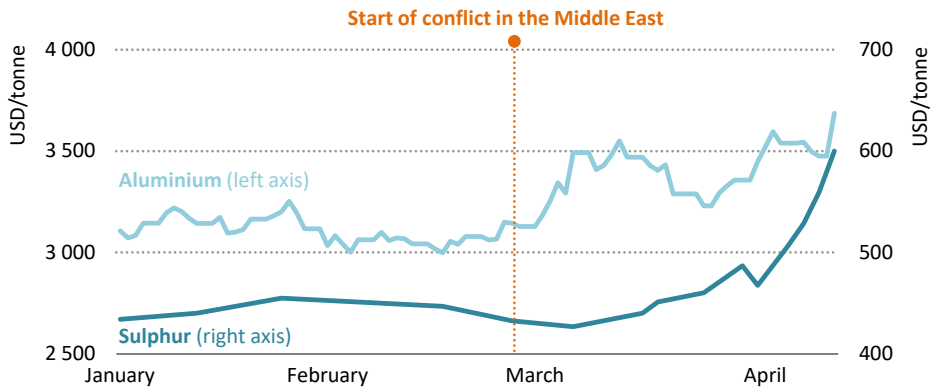
The other main short-term impact of the crisis was to spur consumers, particularly in the worst-affected countries and regions, to look for alternative ways to meet their energy service demand. The available sales and trade data for the first months of the crisis show a sharp pick-up in imports of batteries and solar PV equipment, with some of the largest increases coming in these countries and regions (Figure 2.14). Behind-the-meter battery installations have also grown rapidly, notably in Central and South America and across much of the Asia Pacific region. Meanwhile, electric car sales rebounded in the second quarter of 2026 despite a fall in overall global car sales. In Australia, Brazil, India, Korea and Viet Nam, electric car sales have roughly doubled since the beginning of the crisis.

Critical minerals

While the key impacts were felt in oil and gas markets, the near closure of transit through the Strait of Hormuz also had considerable consequences for mineral and metal markets, particularly for aluminium, sulphur, ammonia, urea and helium. The Middle East accounts for around 8% of global aluminium production, and disruptions at several key regional smelters added pressure to an already tight market, increasing prices (Figure 2.15). The region also supplies around one-quarter of global sulphur, and half of all global seaborne sulphur trade normally passes through the Strait. Sulphur is a critical feedstock for sulphuric acid, which is essential for the production of fertilisers and of a range of metals such as copper, lithium, cobalt, nickel and rare earths. Disrupted sulphur supplies prompted China to curb sulphuric acid exports in May 2026, creating ripple effects across both mineral and fertiliser value chains. The resulting surge in acid prices has increased production costs for several critical minerals, with acid costs in some cases overtaking energy costs to become the largest cost component.

Figure 2.15 ▷ Aluminium and sulphur prices, January-April 2026



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Aluminium and sulphur prices surged after the start of the conflict in the Middle East, with ripple effects for many markets, including fertilisers, metals and chemicals

Sources: IEA analysis based on Bloomberg (2026); China, General Administration of Customs (2026).

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Before the conflict, the Middle East accounted for one-quarter of global ammonia trade and around 40% of urea trade. Like sulphur, these are vital to fertiliser production, and the interruption to supply of these products alongside sulphur has added significant upward pressure on fertiliser prices. The region was also a key supplier of helium, a by-product of natural gas processing and an essential input for semiconductor, fibre optic and medical supply chains, as well as semiconductor-dependent downstream industries. Qatar accounted for roughly 35% of global helium production in 2025, and most of its output has been halted.

Economy

At a global level, the economy has been remarkably resilient. Most economic forecasters have revised down their expectations for global growth in 2026 only slightly compared to forecasts made before the 2026 energy crisis. Despite all the downside risks that came from the energy shock, the International Monetary Fund's forecast for growth in 2026 in its latest World Economic Outlook (IMF, 2026) is 3.1%, only a modest drop from 3.3% in its January forecast before the conflict in the Middle East began. One of the main reasons for this is that concerns about the outlook for energy have been offset by the economic effects of a boom in AI-related investments.

The global numbers hide strong divergences in performance and expectations across countries. There have been substantial hits to growth in economies directly affected by conflict, notably the Middle East. Beyond the region, several emerging market and developing economies reliant on energy imports and without strong fiscal or other buffers have also proved vulnerable. On the other hand, growth prospects have proved more resilient in some large economies benefiting from strong technology-related investment and trade, with forecasts for China and the United States broadly unchanged from before the conflict began and India's revised higher.

The balance of risks to the economic outlook appears weighted to the downside, especially given the extreme tightness in diesel markets and the fundamental importance of diesel to many day-to-day economic activities. A long tail of disruption to shipping in the Strait of Hormuz or a further escalation of hostilities would exacerbate these strains through intensified inflationary pressures and could increase food insecurity. The AI boom could also turn into a source of strain if returns on AI investment disappoint. Other major risk factors include renewed trade tensions, large fiscal deficits, public debt approaching levels last seen in 2020, and high debt servicing costs.

Energy policy developments

Prior to the conflict in the Middle East, a number of countries postponed, revised or introduced greater flexibility into energy and climate policies that were scheduled to take effect in 2026. For example, the European Union's Automotive Package, adopted in December 2025, introduced greater flexibility for heavy-duty vehicle manufacturers in meeting the CO_2 reduction targets established for 2030. Similarly, Canada announced in February 2026 the repeal of its Electric Vehicle Availability Standard, which had established zero-emission vehicle sales targets for manufacturers, and it indicated that it would replace

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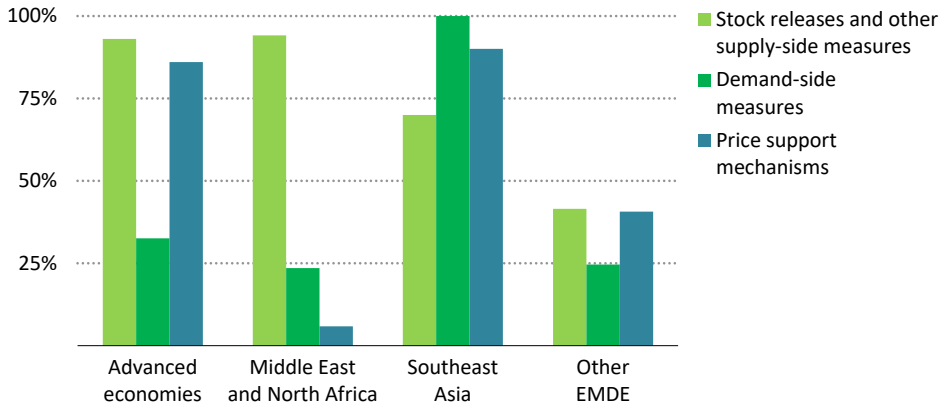
the standard with more stringent greenhouse gas emissions standards to be introduced over the following decade.

Since the conflict in the Middle East began, it has prompted a series of measures by governments to counter its immediate energy impacts. As of September 2026, IEA tracking shows that 115 national governments had enacted new or strengthened policies in response to the conflict (IEA, 2026c). These policies mainly took the form of three kinds of short-term response: stock releases and other supply-side measures, demand-side measures, and price support mechanisms (Figure 2.16).

Figure 2.16 ▷ Share of countries implementing emergency measures by selected grouping, September 2026



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Many countries have taken action to improve affordability in the wake of the 2026 energy crisis, with demand-side measures featuring strongly in Southeast Asia in particular

Strategic petroleum reserves and commercial stocks have a well-established role in mitigating the impact of shortfalls in supply. However, a number of governments also took other temporary supply-side measures. These included the suspension of some operational limitations on coal-fired power plants to allow for more gas-to-coal switching in countries such as Japan and Korea, and measures to make more supply available on international markets, for example via the emergency authorisation of additional LNG supply from the Plaquemines export facility in the United States. Other measures less directly dependent on government authorisation included the postponement of scheduled maintenance at several upstream and midstream assets. Some supply-side policy decisions, such as export restrictions on oil products, added to market strains and uncertainty. China restricted exports of oil products soon after the conflict began, although controls were relaxed somewhat in subsequent months.

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Governments also implemented a range of measures on the demand side to ration supplies to certain sectors, such as petrochemicals and fertiliser production, and to encourage consumers to reduce consumption. Countries heavily dependent on oil and gas passing through the Strait of Hormuz were particularly active on this front. All Southeast Asian countries implemented at least one demand restraint measure; similar measures in advanced economies were less widespread. More than 40 countries initiated energy conservation awareness campaigns, while about 25 countries, including Malaysia, Pakistan and Thailand, implemented transport and speed restrictions. A handful of countries also extended teleworking incentives, issued guidance to limit cooling settings or took action to prioritise access to LPG for particularly vulnerable groups.

Price support mechanisms to mitigate the effects of oil price rises were introduced in many countries, most notably in Europe and Southeast Asia. About 90 countries implemented at least one type of consumer support measure, mostly in the form of fuel tax reductions, price caps, or direct grants or vouchers. Japan earmarked around USD 20 billion to mitigate energy price impacts, EU member states in aggregate USD 13 billion, and Korea USD 7 billion. More than two-thirds of the announced spending was made available to all households, regardless of their income.

In addition to short-term measures aimed at maintaining fuel supply and reducing impacts on end-users, the conflict in the Middle East prompted governments to take steps that are likely to lead to longer-term structural shifts in energy supply dynamics. Many governments in the Middle East in particular are now pursuing new oil pipeline projects that will reduce their reliance on the Strait of Hormuz. Saudi Arabia and the United Arab Emirates have announced plans to expand their respective bypass routes – the Saudi East-West pipeline system and the UAE link to Fujairah. Other producers, notably Iraq, are also resurrecting discussions about alternative routes to market, including a corridor to the Mediterranean.

Longer-term responses have not been confined to the Middle East. Many more are still under consideration, but as of September 2026, around 30 countries had adopted long-term energy policy responses focused on shifting energy demand towards electricity and alternative fuels (Figure 2.17). The largest share of these responses was directed at electrification, reflecting its potential to curb dependence on imported fossil fuels. The European Union released an electrification action plan, which sets targets for 2035 and 2050. Twenty-two governments announced new or extended EV incentive programmes to provide financial assistance, consumer grants, tax credits and import tariff reductions, including a trade-in programme in Thailand to encourage the adoption of electric cars, motorcycles and pick-up trucks. Efforts to accelerate the deployment of heat pumps were strengthened in Europe, Japan and Korea, while policies to incentivise electric cooking were put in place in several emerging market and developing economies. For example, France confirmed its intention to ban gas boiler sales by 2027 and introduce a heat pump leasing programme, while Cambodia and Indonesia introduced new incentive programmes and reduced import duties for electric stoves in April 2026.

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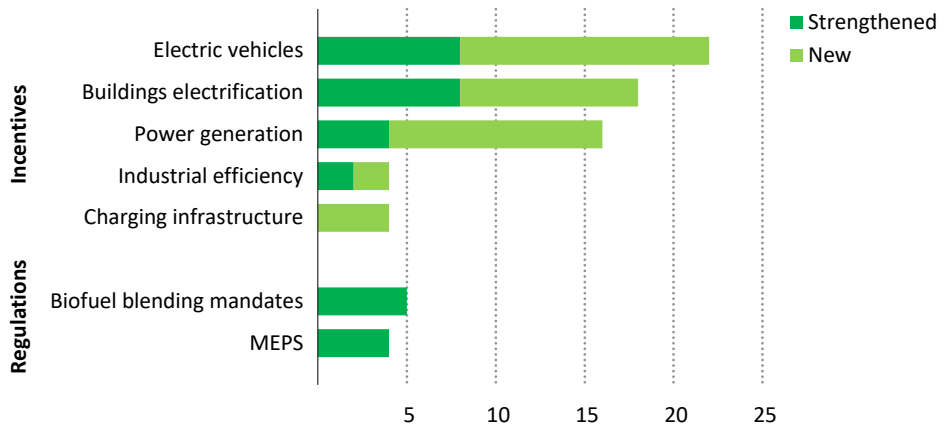
The production and rollout of alternative fuels have also gained momentum since March 2026. Five countries have strengthened their biofuel blending mandates, notably in Southeast Asia. The United States finalised its new Renewable Fuel Standards in March 2026, Viet Nam accelerated its E10 (10% ethanol blend) programme in June, and Indonesia began implementing its B50 (50% biodiesel blend) mandate in July.

Figure 2.17 ▷ Number of measures implemented as part of selected structural policy responses to the 2026 conflict in the Middle East, as of September 2026



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Recent developments in long-term energy policy focused on direct fiscal incentives towards electrification, along with fuel switching regulations

Note: MEPS = minimum energy performance standards.

2.3 WEO scenarios

The World Energy Outlook contains multiple scenarios and cases that set out how the global energy system might develop. None of these is a forecast: the IEA does not have a single view on what the energy sector will look like in 2035 or 2050. Our intention is rather to provide a framework for understanding a range of possible energy futures, along with analysis of how and why they differ and the levers available to policy makers to shape investment decisions and outcomes.

Each of these possible trajectories features rising demand for energy services, to provide lighting, cooling, heating, transport, information and all the other essential elements that underpin modern economies and lives. This increase in demand for energy services is a function of a growing global population and an expanding global economy. However, it can be met in different ways, and government policies play an important role in determining which combination of fuels and technologies is ultimately chosen by firms and households.

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The 2026 Middle East conflict has been a major shock to the energy system. A key objective of this year's *Outlook* is to examine how this shock might affect government policy preferences, particularly among fuel-importing countries, together with what this might mean for energy security, affordability and emissions.

The *Outlook* puts forward two exploratory scenarios, which proceed from different starting conditions and see where they lead the energy system. These scenarios do not have a fixed view on the end point. For example, they do not assume that longer-term goals, such as national or regional net zero targets, are met. We also include one normative scenario – the Net Zero Emissions by 2050 Scenario – that works towards pre-defined goals and maps out ways to realise them.

- The **Current Policies Scenario (CPS)** is an exploratory scenario in which no change in energy-related policies is assumed beyond what was firmly in place as of August 2026, and no further action is assumed on time-limited policies once they expire. Given the time it takes to formally adopt new legislation and regulation, this scenario does not incorporate many policy responses to the Middle East conflict. It does, however, capture some near-term responses and behavioural changes that could have longer-term implications, such as the observed change in consumer purchasing behaviour for EVs and rooftop solar and the easing of operational restrictions on coal-fired power in some countries. The CPS offers a generally cautious perspective on the speed at which new energy technologies are deployed and integrated into the energy system, and it tends to project slower growth in the adoption of new technologies than has been seen in recent years or is projected in the Stated Policies Scenario.
- The **Stated Policies Scenario (STEPS)** builds on a broader reading of the policy landscape than the CPS. Alongside policies already in place, it takes account of concrete policy proposals and official strategy documents that indicate the direction in which governments intend to move. This includes measures developed in response to the Middle East conflict as of August 2026, such as new plans and targets to expand renewable and clean electricity generation (as in Indonesia, Korea and Thailand); new initiatives to support transport electrification (as in the European Union and Indonesia); additional support for energy efficiency improvements (as in Canada, China and Türkiye); and measures to increase the use of biofuels (as in Brazil). In addition, the STEPS offers a more dynamic perspective on energy technology and market trends than the CPS, allowing for a more rapid introduction of new energy technologies.
- The **Net Zero Emissions by 2050 (NZE) Scenario** is the only normative scenario in this year's *Outlook*. It is specifically designed to achieve an ambitious reduction in energy-related emissions. It maps out a way for the global energy system to achieve net zero CO_2 emissions by 2050 and is consistent with a long-term goal of limiting the rise in global average temperatures to 1.5 °C (with a 50% probability). In the light of persistently high emissions in recent years, warming in this scenario peaks just below 1.7 °C and exceeds 1.5 °C for several decades before returning below 1.5 °C by 2100. This requires a very rapid transformation of the energy sector along with the widespread deployment of CO_2 removal technologies.

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This year's *WEO* also includes two new cases – the Additional Response Case and the Low Hormuz Case – that expand our analysis of the potential implications of the Middle East conflict beyond those captured in the exploratory scenarios.

- The **Additional Response Case (ARC)** goes further than the CPS and the STEPS in accounting for possible responses to the disruptions in energy markets in 2026. As discussed in the preceding section, most countries have been focused on managing the immediate impacts of the conflict in the Middle East and have not yet had time to formulate longer-term policy responses that would qualify for inclusion in the CPS or the STEPS. Nonetheless, there are preliminary indications in speeches and other public statements of how governments' longer-term policy priorities could evolve in response to the crisis. The ARC explores what would happen if these potential changes were turned into actionable policy proposals and then implemented. It therefore examines how a more far-reaching response to heightened energy security concerns could reshape the energy system over time. This brings into play a range of additional demand- and supply-side measures, which typically put greater emphasis on efforts to diversify fuel suppliers and import routes; strengthened incentives or frameworks to develop domestically available resources and improve energy efficiency; and a stronger push for electrification of end-use consumption, for instance for transport. Insofar as these measures affect demand for imported oil and natural gas, the response from most exporters is to use more of their production at home, so their domestic energy mix tends more towards what is seen in the CPS. However, this varies by country.
- While the ARC looks at a range of possible additional responses to heightened energy security concerns, the **Low Hormuz Case (LHC)** addresses a specific issue: whether and how the energy world could manage without the transit of energy supplies through the Strait of Hormuz.

The conflict in the Middle East is not over, and there is still a high degree of uncertainty over how and when it might be resolved and how stable any resolution might be. In our scenarios, constraints on exports from the Gulf arising from the conflict are assumed to ease as we move into 2027, and conditions are assumed to be sufficiently stable to allow for unimpeded transit through the Strait by the end of 2027. This does not, however, return the energy world to the situation that existed prior to the conflict, as our exploratory scenarios reflect to different degrees the impact of lasting changes in policies and risk perceptions.

The additional responses and dilemmas examined in our two new cases are pertinent in a world in which the conflict stabilises relatively quickly, as assumed in our scenarios. They become even more relevant if risks to oil and gas supply from the Middle East persist for longer, including in the event of a prolonged stalemate or recurring bouts of hostilities. More so than our scenarios, these cases depict an unstable international environment, in which energy security concerns are even more prominent and confidence in Middle East exports and reliable rules-based international trade is diminished.

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2.3.1 GDP and population

The global economy is assumed to grow by 3% on average annually to 2035 across all scenarios and then to slow in subsequent years through to 2050 (Table 2.1). Our gross domestic product (GDP) assumptions at a country and regional level to 2030 are based on the *World Economic Outlook* released by the International Monetary Fund (IMF) in October 2026 (IMF, 2026). GDP growth assumptions from 2030 onwards are based on Oxford Economics forecasts (Oxford Economics, 2026) and the application of the Solow growth model (World Bank, 2022). The Solow model estimates future GDP on a country and regional basis by accounting for labour supply, capital stock and total factor productivity (TFP). TFP growth reflects catch-up dynamics in lower-income countries and their gradual convergence towards advanced economy levels.[1] Economic assumptions are held constant across the various scenarios to facilitate comparisons between them, although we recognise that decisions taken by policy makers in the energy sector may have broader economic implications.

Table 2.1 ▷ GDP average growth assumptions by region

	Compound average annual growth rate			
	2015-25	2025-35	2035-50	2025-50
North America	2.3%	1.9%	1.8%	1.9%
United States	2.4%	2.0%	1.8%	1.9%
Central and South America	1.2%	2.6%	2.0%	2.2%
Brazil	1.4%	2.3%	2.1%	2.2%
Europe	1.9%	1.6%	1.2%	1.4%
European Union	1.7%	1.3%	0.9%	1.0%
Africa	2.8%	4.3%	4.0%	4.1%
South Africa	0.6%	1.7%	2.3%	2.0%
Middle East	2.3%	3.0%	2.7%	2.8%
Eurasia	2.3%	1.8%	1.6%	1.7%
Russia	1.8%	0.9%	0.5%	0.7%
Asia Pacific	4.5%	3.9%	2.7%	3.2%
China	5.5%	3.5%	2.2%	2.7%
India	5.8%	6.2%	3.9%	4.8%
Japan	0.5%	0.6%	0.7%	0.7%
Southeast Asia	4.0%	4.4%	3.0%	3.6%
World	**3.1%**	**3.0%**	**2.4%**	**2.6%**

Note: Calculated based on GDP expressed in year-2025 US dollars in purchasing power parity terms.

Sources: IEA analysis based on IMF (2026); Oxford Economics (2026).

[1] Details on GDP and other macroeconomic assumptions are available in the IEA GEC-Model documentation (IEA, 2026d).

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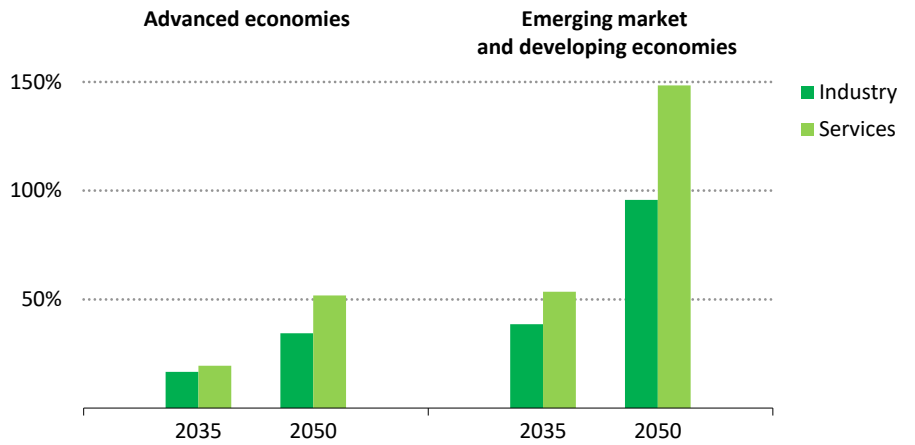
The annual value added by the industry and services sectors is assumed to grow to 2035 by a compound average of 2.7% and 3.1%, respectively. The services sector in emerging market and developing economies sees the fastest rise in economic output, reflecting a more rapid overall growth trajectory and a continued shift towards services-based economic activity (Figure 2.18).

Figure 2.18 ▷ Change in annual value added in 2035 and 2050 compared with 2025



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While industry continues to expand, services increasingly drive value-added growth in emerging market and developing economies

The global population is expected to rise from 8.2 billion in 2025 to 9.6 billion in 2050, with annual growth slowing from 0.8% in the late 2020s to 0.5% in the 2040s. The numbers used are based on the medium population projection of the United Nations World Population Prospects (United Nations, 2024) and are in line with the projections in *WEO-2025*.

Population growth varies widely between regions. By 2050, Africa's population is projected to increase by 916 million, and the population of Asia Pacific excluding China and India is set to rise by 248 million. By contrast, the populations of China and Europe are projected to decrease. The pace of growth in GDP per capita also varies markedly by region, depending on factors such as demographic composition, workforce participation and productivity (Figure 2.19). Regions such as Asia Pacific and Central and South America are projected to see strong increases in GDP per capita alongside a relatively moderate population increase and, in China's case, an overall population decline.

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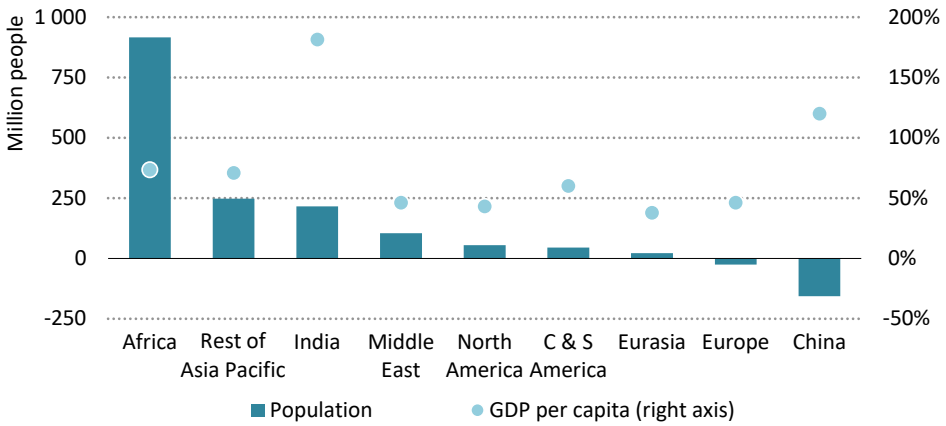
Figure 2.19 ▷ Change in population and GDP per capita by region, 2025-2050



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Some regions are projected to see robust economic growth across a variety of demographic trajectories

2.3.2 Prices

Oil prices

Oil prices in the *World Energy Outlook* are shaped by the interaction between global supply and demand, and they evolve to maintain balanced markets over time (Table 2.2). The trajectories presented do not capture the short-term volatility that characterises markets in practice. Oil markets were well supplied coming into the 2026 conflict in the Middle East, but prices have since risen sharply and are assumed to remain high into 2027. However, pre-crisis supply is assumed to return to the market following a recovery in Middle East production. This leads price pressures to moderate, with the equilibrium determined by variations in projected demand. Additional supply from regions such as Central and South America and higher output from the United Arab Emirates following its withdrawal from OPEC also contribute to looser near-term market conditions.

In the Current Policies Scenario, oil demand continues to expand, amplifying the need for ongoing investment in supply. As lower-cost resources mature and production from existing fields falls back, higher-cost supply is required to meet rising demand, putting upward pressure on prices. Price trends are closely linked to the ability of major producers to maintain output levels and to mobilise sufficient investment in new capacity.

In the Stated Policies Scenario, demand growth slows markedly compared with the CPS, and demand eventually falls back slightly, somewhat easing the pressure on global supply. Prices rise more moderately than in the CPS to 2035 and then start to fall as demand weakens. Substantial continued investment is nonetheless required to offset natural field declines.

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Table 2.2 ▷ Wholesale fossil fuel prices by scenario

		CPS		STEPS		ARC		NZE	
USD (2025, MER)	2025	2035	2050	2035	2050	2035	2050	2035	2050
IEA crude oil (USD/barrel)	68	85	106	75	70	72	62	34	26
Natural gas (USD/MBtu)									
United States	3.5	4.7	5.0	4.1	4.6	4.0	4.4	2.1	2.0
European Union	11.1	9.4	10.5	5.7	8.9	6.1	5.4	4.2	4.0
China	9.8	9.9	11.2	6.4	9.5	7.2	6.3	4.9	4.9
Japan	12.6	10.9	12.4	6.8	9.9	7.1	5.8	4.9	4.9
Steam coal (USD/tonne)									
United States	55	58	55	44	41	58	56	26	25
European Union	99	97	85	82	71	79	65	49	41
Japan	117	124	105	109	94	104	87	63	51
Coastal China	107	120	105	107	98	107	98	61	53

Notes: MBtu = million British thermal units; CPS = Current Policies Scenario; STEPS = Stated Policies Scenario; ARC = Additional Response Case; NZE = Net Zero Emissions by 2050 Scenario. The IEA crude oil price is a weighted average of import prices among IEA Member countries. Natural gas prices are weighted averages expressed on a gross calorific-value basis and exclude regasification charges. The US natural gas price reflects the wholesale price prevailing on the domestic market. Natural gas prices in the European Union and China reflect a balance of pipeline and liquefied natural gas (LNG) imports, while the Japan gas price is solely for LNG imports. LNG prices are those at the customs border prior to regasification. Steam coal prices are weighted averages adjusted to 6 000 kilocalories per kilogramme. The US steam coal price reflects mine mouth prices plus transport and handling costs. The coastal China steam coal price reflects a balance of imports and domestic sales, while the EU and Japanese steam coal prices are solely for imports. Wholesale prices exclude any emissions pricing applied at the point of use.

In the Additional Response Case, oil demand is lower than in the STEPS in 2035. Prices are moderated further by policies that encourage domestic oil production, including measures that reduce government tax and royalty revenues where production remains economically and geographically viable.

In the Net Zero Emissions by 2050 Scenario, a rapid contraction in oil demand leads to a structurally much looser market. Prices fall significantly as supply increasingly reflects the cost structure of the most competitive producers. Strong policy support is assumed to prevent lower prices from triggering a rebound in demand and to keep the system aligned with net zero objectives.

Natural gas prices

Natural gas prices vary across regions, reflecting differences in resource availability, infrastructure and exposure to international gas trade. With the rise of LNG trade, an increasing number of flexible cargoes are being redirected to markets willing to pay the highest price, and prices across the Atlantic and Pacific basins have become more interlinked.

The regional benchmarks for China, the European Union and Japan presented in Table 2.2 are weighted average import prices that reflect the share of volumes in each region imported under oil-linked contracts and those priced on the spot market. In Europe, around 80% of gas

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is hub-priced today, whereas in Asia, the share is around 30%. Over the long run, the share of gas priced using oil indexation falls in all scenarios, and price differentials between Asia and the European Union primarily reflect the difference in transport costs associated with LNG supply.

In the near term, prices remain high across all our scenarios, but this period of tighter market conditions is assumed to be short-lived as and when Qatari LNG exports resume. Substantial LNG export capacity comes online through the second half of the 2020s, and most production losses associated with disruptions during the 2026 energy crisis are assumed to be restored before the end of the decade. As the US share of globally traded gas grows from almost zero in 2015 to more than 25% in 2035 in the CPS and the STEPS, its domestic reference price (Henry Hub) becomes an increasingly important global benchmark for internationally traded gas.

In the Current Policies Scenario, continued growth in gas consumption steadily absorbs most of the new LNG supply entering the market. Prices in key importing regions average around USD 10 per million British thermal units (MBtu) in 2035, as growing demand largely offsets the downward pressure from expanding LNG supply.

In the Stated Policies Scenario, slower growth in gas demand, particularly in importing regions, means that the new LNG supply set to come online in the next few years is not fully absorbed by the market. Demand response to lower prices is not sufficient to clear the overhang, which pushes import price benchmarks down to near the short-run marginal cost of supply, putting pressure on LNG project cost recovery.

In the Additional Response Case, import prices in 2035 are marginally higher than in the STEPS. Buyers are more willing to pay a security premium for imported gas and to rely on long-term contracts with indexed prices, which can slow the pass-through of lower spot prices to weighted average import prices. This effect is more pronounced than in the STEPS, in which a larger share of gas is traded on the spot market and prices therefore respond more directly to near-term supply-demand imbalances. However, the upward pressure on prices in the ARC is partly offset by policies to reduce natural gas demand and measures to increase domestic supply and limit reliance on imports.

In the Net Zero Emissions by 2050 Scenario, rapidly falling gas demand widens the surplus of gas supply even further, resulting in prices that fall well below long-run costs.

Coal prices

Coal prices remain relatively firm in the near term across all scenarios, reflecting tighter market conditions and higher prices for competing fuels than in the recent past. However, over the longer term, price trajectories are driven primarily by the outlook for coal demand (Table 2.2).

In the Current Policies Scenario, a moderate decline in global demand to 2050 keeps prices higher than in other scenarios. Prices remain high in the United States as coal continues to compete with natural gas, while in the European Union, they ease as demand falls. In coastal

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China and Japan, stronger near-term demand tightens the global seaborne market and supports prices, although structural declines in demand put downward pressure on prices over the longer term.

In the Stated Policies Scenario, steeper reductions in coal consumption lead to lower prices across all regions. Prices in the European Union fall sharply as domestic demand weakens, while in the United States, gradual plant retirements contribute to a steady decline. Prices in coastal China and Japan also trend lower, with Japan largely tracking developments in the Chinese market.

In the Additional Response Case, internationally traded steam coal demand declines more rapidly than in the STEPS. Lower imports across the Pacific Basin ease pressure on seaborne markets, reducing prices in importing regions such as the European Union and Japan. In the United States, higher domestic demand and production support higher prices. Prices in coastal China remain broadly in line with those in the STEPS as stronger demand is offset by higher production and lower import volumes.

In the Net Zero Emissions by 2050 Scenario, coal demand contracts rapidly in all regions, leading to a steep decline in prices as production is increasingly concentrated among the lowest-cost suppliers.

Critical mineral prices

Critical mineral prices play an increasingly important role in the energy sector. While they do not have the same direct influence on near-term energy prices as fuels, they are a major determinant of the cost and competitiveness of key energy technologies, and thus of the pace of electrification. Lithium, nickel, cobalt and graphite are essential for current battery manufacturing, and copper is fundamental for electricity networks. Following a downturn in 2023-2024, many critical mineral markets strengthened in 2025 and the beginning of 2026. Prices for base metals such as copper, aluminium and tin rose amid tightening supply and growing demand, with copper prices reaching record highs in early 2026. Battery metal prices also recovered, with lithium, cobalt and nickel all increasing from their recent lows, although graphite prices remained subdued due to continued oversupply. Price increases for nickel and cobalt were largely driven by policy changes in Indonesia and the Democratic Republic of the Congo, the leading suppliers, respectively, for these battery metals. Export controls and other policy measures also added to market pressures for rare earths and several strategically important minor minerals.

We do not model future critical mineral prices in the same way as fuel prices, given the wide range of demand sources outside the energy sector. However, our assessment of technology trends, market balances and supply chain developments provides insights into potential price pressures. Copper remains a particular concern as demand continues to increase for its use in grids, clean energy technologies, construction and industrial applications, while supply growth is constrained by declining ore grades. This is leading to higher capital costs, greater project complexity and longer project lead times. Although supply growth has generally kept pace with rising demand for battery minerals, recent market developments highlight the

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growing influence of policy measures, export restrictions and geopolitical events on prices. The conflict in the Middle East has also exposed vulnerabilities in critical mineral supply chains, with shipping disruptions affecting aluminium and key processing inputs for copper, nickel and cobalt, such as sulphur. More broadly, the concentration of mining, refining and processing capacity for many critical minerals means that supply disruptions, trade restrictions or investment shortfalls could have significant implications for both prices and availability of supply.

Carbon prices

Compliance carbon pricing instruments, including emissions trading systems, carbon taxes and hybrid approaches, generated an estimated USD 107 billion in revenues globally in 2025, around 2% more than in 2024. Nearly half of these revenues came from the European Union's Emissions Trading System (ETS). A few carbon pricing systems have recently been revised, postponed or repealed, including the EU ETS 2 for buildings and transport, which has been postponed to 2028, and the UK Carbon Price Support, which will be discontinued in 2028. However, 2026 also marked the start of the EU Carbon Border Adjustment Mechanism and saw a reduction of free allowances for industry in the European Union, as well as the launch of new schemes in Mauritania, Nigeria and Serbia. At the sectoral level, global coverage of industrial emissions expanded significantly from 15% in 2024 to nearly 60% in 2025, driven by China's extension of its ETS to the cement, steel and aluminium sectors. In the power sector, around 59% of global emissions are covered by a carbon price, and this share could rise to 70% by 2030 as emerging market and developing economies like Brazil start implementing their schemes.

Carbon price trajectories vary across scenarios. The Current Policies Scenario includes only carbon pricing systems that are already in force and excludes scheduled schemes and planned reforms. The STEPS and the ARC incorporate existing and announced systems, including planned expansions in sectoral coverage and the phase-out of free allowances. The NZE Scenario includes additional measures and stronger price signals in all regions. Carbon prices in the scenarios do not represent marginal abatement costs and do not exist in isolation: they should be considered alongside other policy measures, including regulations, standards and incentive programmes. (See Annex B for price trajectories by region.)

2.3.3 Technology costs

Technology cost trajectories in our scenarios reflect the interaction of learning effects, economies of scale and resource availability. The modelling framework does not assume major technological breakthroughs but rather incorporates a detailed portfolio of technologies across all energy sectors, including emerging options that are approaching commercial maturity. Costs evolve differently across scenarios depending on deployment rates, technological maturity and underlying demand trends. For renewables and batteries, faster deployment accelerates cost reductions through learning-by-doing and innovation. By contrast, fossil fuel extraction costs reflect a balance between resource depletion and technological improvements, with variations by project type and region.

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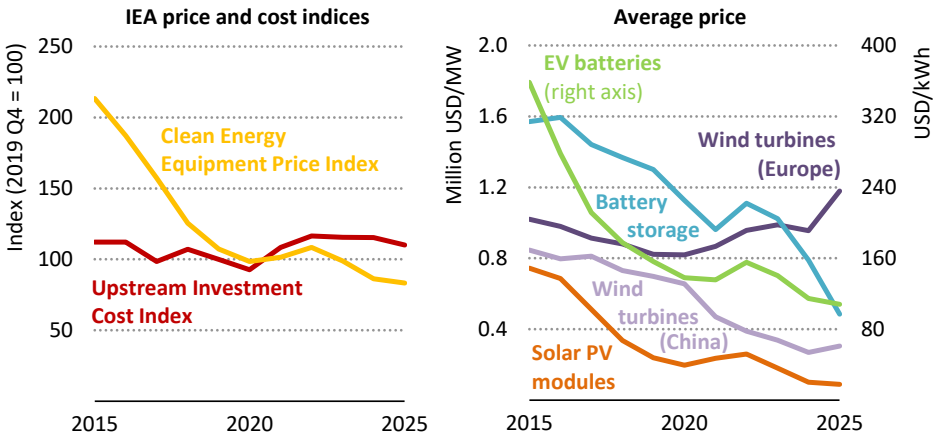
The IEA Upstream Investment Cost Index tracks changes in a basket of input costs for oil and gas projects worldwide, including materials, rig rates, labour and fuel. The index is constructed as an investment-weighted average of costs across conventional and unconventional oil and gas production (Figure 2.20). It indicates that average upstream unit costs have remained relatively stable in recent years, despite higher service costs linked to the strong utilisation of specialised equipment. At the same time, efficiency gains, including advances in well design and field development, meant that conventional oil projects developed in 2025 had costs more than 15% below the 2015-2019 average (IEA, 2025).

Figure 2.20 ▷ Indices of clean energy equipment prices and upstream oil and gas capital costs, and global average price of selected energy technologies, 2015-2025



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Clean energy technology prices continue to fall, with battery storage seeing the largest decline at almost 40% in 2025

Notes: MW = megawatt; kWh = kilowatt-hour; Q4 = 4th quarter; EV = electric vehicles. Nominal prices. Battery storage is based on four-hour storage. EV batteries include pack and cell prices. Wind turbines include onshore and offshore prices from European and Chinese producers.

Sources: IEA analysis based on company financial reports and data from BNEF (2026).

The IEA Clean Energy Equipment Price Index tracks historical price trends for a basket of solar PV modules, wind turbines, utility-scale batteries and EV batteries, weighted by investment shares (Figure 2.20). Following the supply chain disruptions and critical mineral price spikes of 2021-2022, lower raw material costs, the scaling up of manufacturing and intense competition among suppliers drove down prices for most clean energy technologies in 2025. Within the index, batteries and solar PV experienced the largest fall in prices, extending a longer-term trend that has reduced costs for both technologies by around 70% since 2015.

Average battery prices continued to decline in 2025 following the record reductions seen in 2024. The decline was led by utility-scale battery storage, which saw prices decrease by just

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under 40%. Technology and manufacturing improvements, low battery mineral prices, manufacturing overcapacity and intense competition across the supply chain continued to drive down costs, while the growing adoption of lower-cost lithium iron phosphate (LFP) batteries added further downward pressure. In 2025, LFP batteries accounted for over half of global EV battery deployment and over 90% of new stationary storage installations, supported by lower production costs and ongoing technological improvements. Regional price differences remain significant and are widening; batteries in China are on average 30% cheaper than in North America and 35% cheaper than in Europe.

Solar PV module prices declined by more than 10% year-on-year in 2025 amid persistent excess manufacturing capacity. However, prices have since ticked upwards due to a spike in the cost of silver, a key input in cell manufacturing, and the removal of China's export tax rebate. Competition among manufacturers, particularly in China, continues to compress margins across the supply chain from polysilicon production to module assembly. Despite efforts to improve market balance, global production capacity still exceeds demand by a considerable margin. As a result, solar PV costs remain well below historical averages, reinforcing the technology's position as one of the most cost-competitive sources of new electricity generation in many markets.

Wind turbine price trends have diverged across regions in recent years. Prices for European turbines were stable or modestly lower in euro terms in 2025, but they increased when expressed in dollar terms because of exchange rate movements. Meanwhile, the price of Chinese wind turbines has fallen markedly over the last few years, widening the gap with many European competitors. The relatively low prices of Chinese wind turbines are made possible in part by large-scale manufacturing underpinned by the size of China's domestic market, and by government financial support that includes below-market loans (IEA, 2026e).

In the nuclear industry, several large-scale reactor projects in advanced economies have faced delays and cost overruns due to first-of-a-kind designs, evolving safety requirements and the need to rebuild supply chains after long periods without new construction. These experiences have generated valuable learning effects, and construction timelines and delivery performance for subsequent projects are expected to improve as designs are replicated and industrial capabilities recover. By contrast, countries with continuous build programmes, such as China, Korea and Russia, have generally done better in controlling costs and avoiding delays. For example, over the past 15 years, Chinese-designed reactors have typically reached their first grid connection within five to seven years of starting construction.

Strong demand for gas-fired capacity, particularly to support data centre growth in the United States, has driven a rise in global average gas turbine prices of more than 30% since 2021. These increases reflect tight supply chains and growing order backlogs rather than significant changes in the underlying technology, with some buyers paying premiums to secure earlier delivery amid limited manufacturing capacity.

Electricity networks have seen major price increases in recent years, with cable prices nearly doubling and transformer prices rising by 75% since 2019. Networks face further cost pressures as grid expansion accelerates. Copper prices reached record highs in 2026, and

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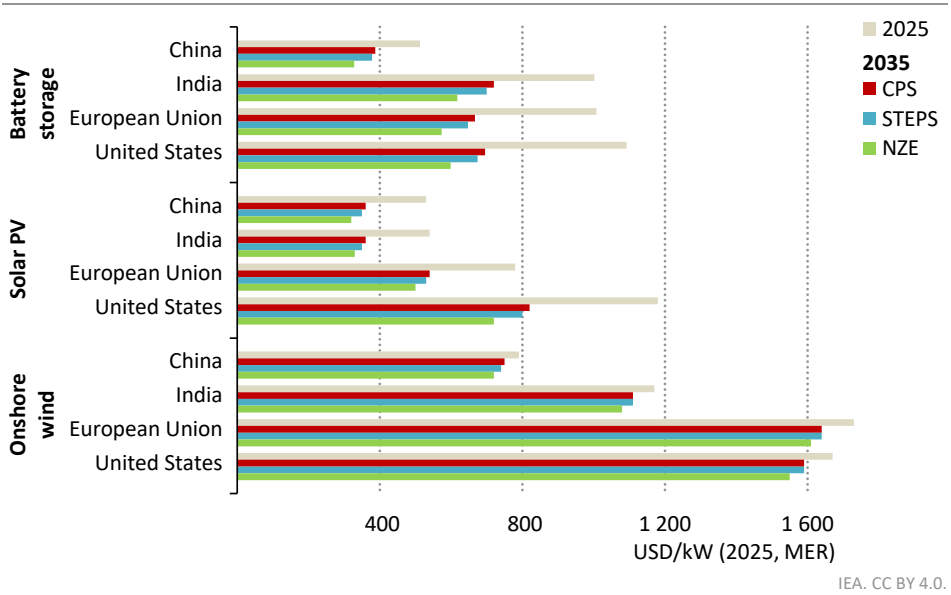
delivery times for large transformers and specialised high-voltage equipment can now extend to several years. Manufacturers have responded to this strong demand signal by expanding their production capacity, with new factories set to begin operations in the coming years.

Looking ahead, installed costs of solar PV, onshore wind and battery storage continue to decline in all our scenarios, although at varying rates by technology, region and deployment level (Figure 2.21). Reductions in cost are supported by continued technological innovation, economies of scale and learning-by-doing. The cost of capital remains an important determinant of affordability, especially in emerging market and developing economies. Recent experience suggests that cost trajectories are unlikely to be smooth and linear. Together with the high degree of concentration seen in manufacturing, this underlines the importance of resilient and diversified supply chains.

The competitiveness of these technologies is discussed further in Chapter 4 (Box 4.7), while detailed regional technology cost assumptions are presented in Annex B.

Figure 2.21 ▷ Installed costs of selected technologies by scenario and region, 2025 and 2035



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Installed costs of renewables and battery storage decline in all scenarios, driven in large part by deployment levels and learning effects

Notes: kW = kilowatt. Battery storage is based on four-hour storage. Installed costs refer to the total upfront cost of deploying a technology, including equipment, construction, engineering and installation costs, expressed per unit of capacity.

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PART B

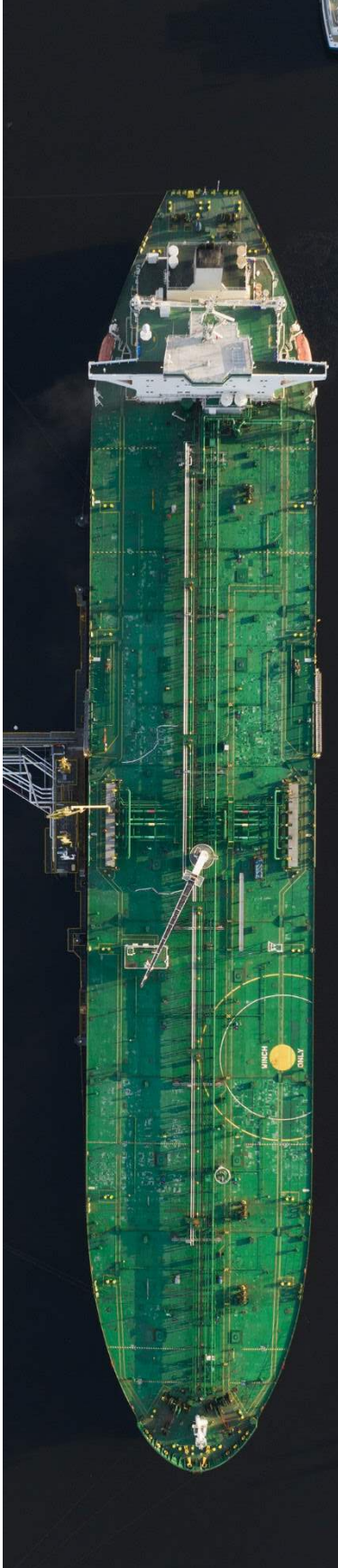
EXPLORING RESPONSES TO THE CRISIS

Part B of the *World Energy Outlook* explores how the energy system could evolve after the 2026 energy crisis. It looks at existing trends and policies and also at additional responses that governments are considering. None of the scenarios or cases that it discusses is a forecast or prediction.

Chapter 3 explores the Current Policies Scenario. It considers only policies and regulations that had been formally adopted by August 2026 and takes a cautious view of how quickly new energy technologies can be deployed and integrated into the energy system. Structural trends that were underway before the conflict in the Middle East continue in this scenario, but they do not speed up.

Chapter 4 examines the Stated Policies Scenario. It considers policies that have been formally tabled but not yet adopted as well as those that are in place. It takes a more dynamic view of policy, technology and market trends than the Current Policies Scenario, which gives it more scope to reflect how governments, markets and investors respond to the 2026 energy crisis.

Chapter 5 examines the possible effects and implications of potential responses to the crisis that go beyond those in the Current Policies Scenario and the Stated Policies Scenario. The Additional Response Case looks at measures that fuel-importing and fuel-exporting countries are considering, such as electrifying end-uses more quickly, developing more domestic resources and diversifying supply routes and sources. The Low Hormuz Case looks at how quickly the world could reduce its reliance on oil and gas flows through the Strait of Hormuz.



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The Current Policies Scenario

Where does the current take us?

SUMMARY

- The Current Policies Scenario (CPS) examines the implications of existing policy settings and illustrates how the energy system would evolve in the absence of further policy action. In this scenario, market and investment trends that predated the current conflict in the Middle East reassert themselves, although the annual rise in global energy demand slows from 1.6% between 2015 and 2025 to 1.2% between 2025 and 2035.
- There is no peak in total fossil fuel demand in the CPS, although coal, the fastest-growing fossil fuel since 2020, enters a period of structural decline. Energy demand increases by 27% between 2025 and 2050, while the share of fossil fuels in the global energy mix falls from 79% to 65%. Global carbon dioxide emissions in the CPS are around 38 gigatonnes in 2050, barely changed from today's level. This leads to a surface temperature rise of around 2 degrees Celsius (°C) in 2050 and 2.9 °C in 2100.
- Average annual energy demand growth in China slows to less than 1% over the period to 2035. As China's growth slows, the engines of global energy demand growth shift over time to India, Southeast Asia and other emerging market and developing economies. India becomes the fastest-growing major destination for energy investment, with spending up 85% by 2035 from its 2025 level.
- Oil demand grows to 114 million barrels per day (mb/d) in 2050, although its consumption share falls in some sectors and regions. Policies promoting electrification, efficiency and biofuels cut passenger car oil use by 0.5 mb/d between 2025 and 2035, a reduction more than offset by a combined 5 mb/d increase for heavy freight trucks, aviation and petrochemicals. Natural gas demand grows strongly, backed by a wave of new liquefied natural gas supply.
- Once the conflict in the Middle East eases, the return of ample supply pushes near-term prices for oil and natural gas down. But these prices need to pick up again strongly in the 2030s to incentivise the new exploration and development that is needed in the CPS to keep supply and demand balanced. Middle East oil and gas exports rise above pre-crisis levels, and the United States overtakes China to become the world's largest producer of fossil fuels after 2035.
- Electricity demand grows strongly in the CPS and is met by higher output from a range of sources. Growth in renewables generation over the next decade is 85% larger than in the past decade, and solar photovoltaics becomes the largest source of electricity globally from the late 2030s. Nuclear makes a comeback, while the share of natural gas declines slightly to 20% of the global electricity mix. Grid spending surges 75%, making networks one of the biggest energy investment stories of the next decade.

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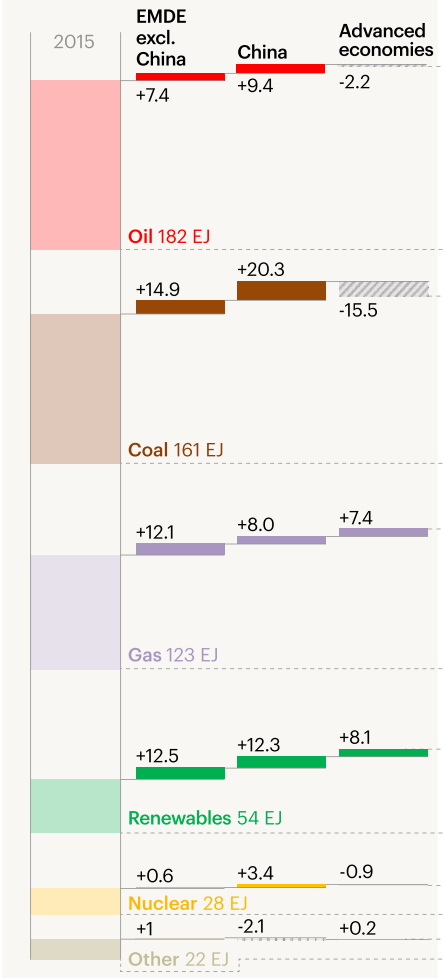
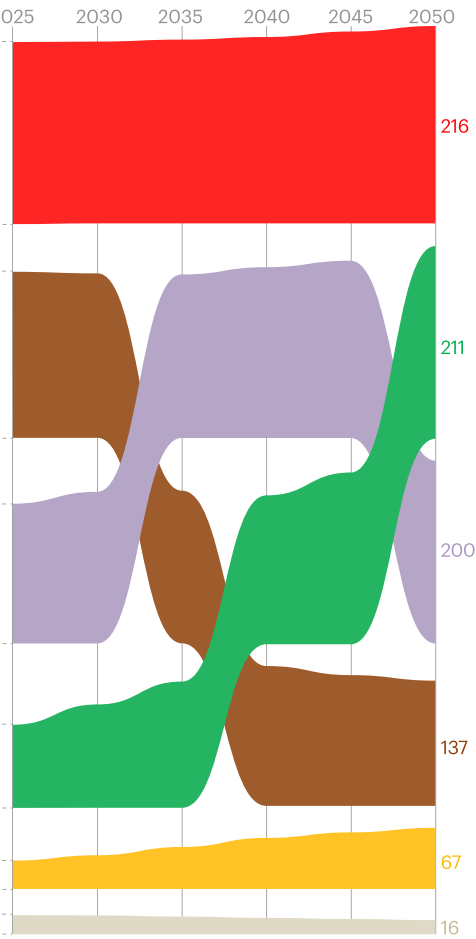
Global energy supply by fuel and changes by region, 2015-2025

China led growth over the past decade. Looking ahead, other emerging economies take over.



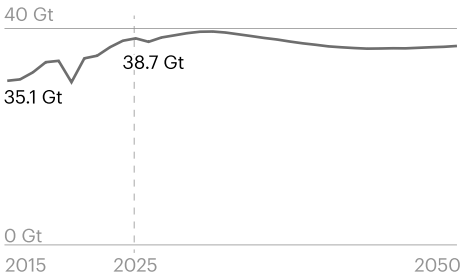
Change in global energy demand in the CPS, 2025-2050

By 2035, natural gas becomes the second-largest energy source, before ceding to renewables by 2050.



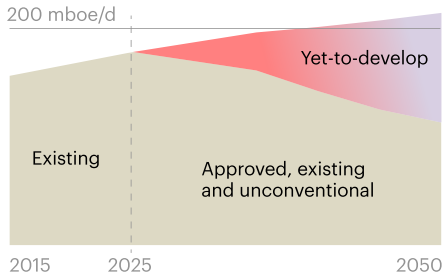
Global energy-related CO_2 emissions in the CPS, 2015-2050

Emissions stay broadly flat at around 38 Gt to 2050



Oil and natural gas resources developed in the CPS, 2025-2050

Around 100 mboe/d of new supply is needed by 2050 to offset declines in existing fields.



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3.1 Introduction

The Current Policies Scenario (CPS) considers only those policies and regulations that had been formally implemented by August 2026, and it does not assume any strengthening or weakening of these policies. It also takes a cautious view on how quickly new technologies can be introduced into the system. Assumptions on the conflict in the Middle East are shared with the Stated Policies Scenario (STEPS). In both scenarios, constraints on exports from the Gulf arising from the conflict ease into 2027, and conditions are assumed to be sufficiently stable to allow for unimpeded transit through the Strait of Hormuz by the end of 2027.

While the CPS reflects short-term crisis measures adopted in response to the conflict in the Middle East, the disruptions do not have many lasting implications in this scenario. There is an immediate dent in gross domestic product (GDP) growth, but relatively little visible impact on longer-term trends. Structural changes that were underway prior to the conflict continue, but they do not accelerate. There is no long-term reduction in Middle East exports or in traded fuels more generally. In practice, this is close to being a necessary condition for the CPS: in a world of continued high demand for oil and natural gas, there is relatively little room for any supplier to underperform, and all major oil and gas resource holders need to invest heavily to avoid renewed bouts of fuel price volatility.

This chapter describes the energy projections in the CPS, starting with an overview of demand and emissions trends and then going into detail on the end-use and electricity sectors. Underlying energy service demand in the CPS is similar to that in the other scenarios in the *World Energy Outlook*, but the mix of fuels and technologies used in the CPS to meet this demand tends to be less efficient than in other scenarios, resulting in higher levels of overall energy use and emissions.

The chapter then moves on to consider trends in demand and supply for oil, natural gas and coal in the CPS and to look at the extent of capital spending required to offset declines at existing fields in order to meet demand. There is a particular focus on the refining sector and the scope for importing countries to meet more of their domestic product demand, and some discussion of the way that countries – notably in Asia – respond to the rising availability of liquefied natural gas (LNG). The concluding sections assess the overall implications of the CPS for investment and employment.

3.2 Overview

3.2.1 Total energy demand

Global energy demand grew by an annual average of 1.6% between 2015 and 2025 (Figure 3.1). The 2026 energy crisis and price spikes caused by the interruption of flows through the Strait of Hormuz disrupt this growth trend in the short term, but the pre-existing direction of structural change remains (Box 3.1). Total energy demand growth slows in the CPS, falling to 1.2% per year from 2025 to 2035 and to 0.8% from 2035 to 2050. By 2035, total energy demand is 12% higher than in 2025, and by 2050, it is 27% higher.

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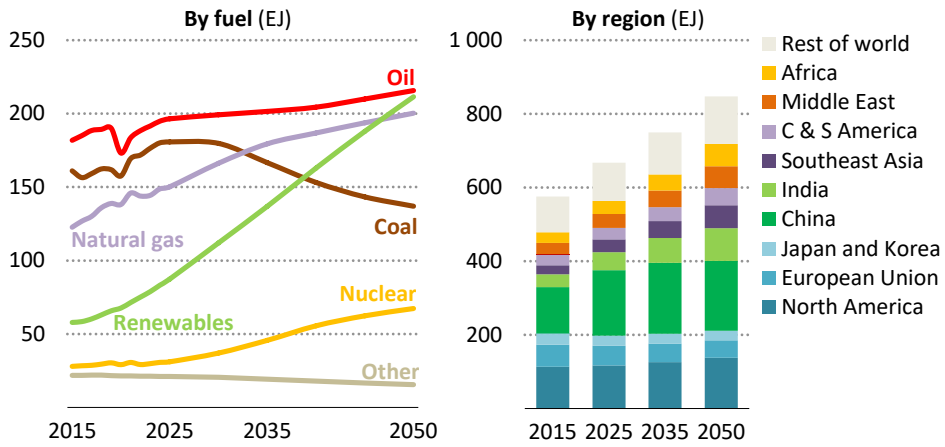
Fossil fuel demand continues to increase in the CPS, but more slowly than over the past decade. Oil demand grows by an average of 0.4% per year over the period to 2035, compared with 0.9% between 2015 and 2025. Natural gas demand, which has grown by an average of 2.0% per year since 2015, rises by 1.8% per year out to 2035 and then by 0.7% annually from 2035 to 2050. Demand for coal, the fastest-growing fossil fuel since 2020, shifts to a downward trajectory, declining by an average of 1.1% per year from 2025 to 2050, when it is one-quarter below its peak. By 2050, fossil fuels meet 65% of total energy demand, compared with 79% in 2025. Oil retains the largest share of the global energy mix in 2050, narrowly ahead of renewables.

Nuclear and renewables keep growing in the CPS. Renewables demand increases at an average annual rate of 4.6% from 2025 to 2035, similar to the rate of 4.8% between 2015 and 2025, and then at 2.9% between 2035 and 2050. Despite this slowdown in the annual rate of growth, renewables demand grows sufficiently fast to overtake demand for coal by 2040 and natural gas by 2050. Stronger support for nuclear energy translates into a marked acceleration in annual demand growth, from around 1% over the last decade to around 4% in the period to 2035.

Figure 3.1 ▷ Energy demand by fuel and region in the CPS, 2015-2050



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Total energy demand continues to grow, driven in large part by emerging market and developing economies outside China

Notes: EJ = exajoule; C & S America = Central and South America. Other includes traditional use of biomass and non-renewable waste.

Over the past decade, China accounted for half of global energy demand growth. In the CPS, its demand growth slows sharply as the country shifts towards a more efficient and electrified system (Section 8.8). China's demand growth falls from an average annual rate of 3.5% between 2015 and 2025 to 0.8% from 2025 to 2035 before demand reaches a plateau

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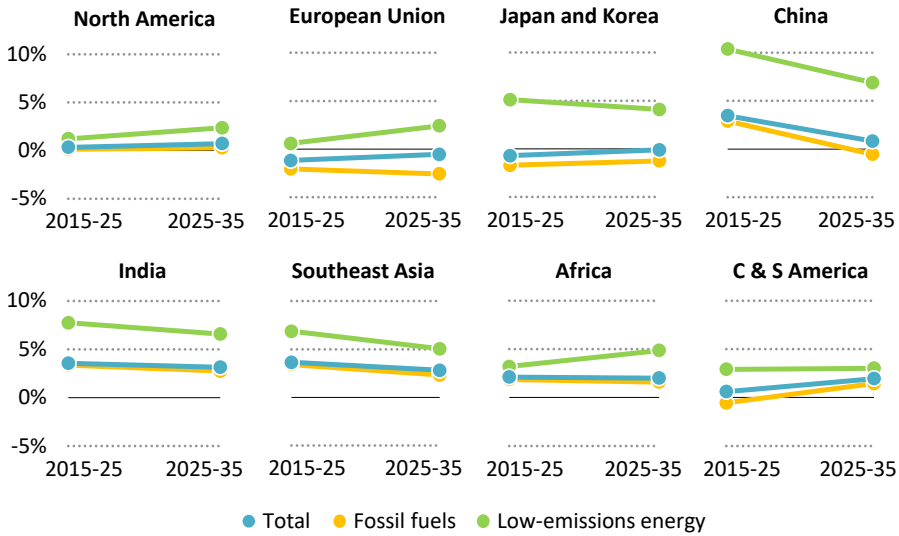
in the late 2030s (Figure 3.2). The centre of global demand growth shifts to India and Southeast Asia, where demand continues to increase broadly in line with historical trends; together, they account for over a third of global energy demand growth between 2025 and 2035.

Figure 3.2 ▷ Average annual change in energy demand, selected regions in the CPS, 2015-2035



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China's growth rate decelerates, and it joins regions such as the European Union in having low-emissions energy growth paired with declining fossil fuels

Total energy demand growth in advanced economies averages 0.3% per year from 2025 to 2035, reversing the average decline of 0.1% per year from 2015 to 2025. Energy demand decreases in the European Union and Japan through to 2035, but this is offset by energy demand growth in North America at an average annual rate of 0.7% to 2035, led by the United States and driven in part by rapid data centre expansion.

Box 3.1 ▷ What has changed in this year's CPS?

A comparison of the outlook provided by this year's Current Policies Scenario with that in the *World Energy Outlook 2025* (*WEO-2025*) highlights some key changes over the last year in underlying trends across the energy sector.

Total energy demand by 2035 is 5.4 exajoules (EJ), or 0.7%, higher in this year's CPS than it was in *WEO-2025* (Figure 3.3). There are pronounced changes in the energy demand outlook in some regions, both upwards and downwards. Among the largest downward

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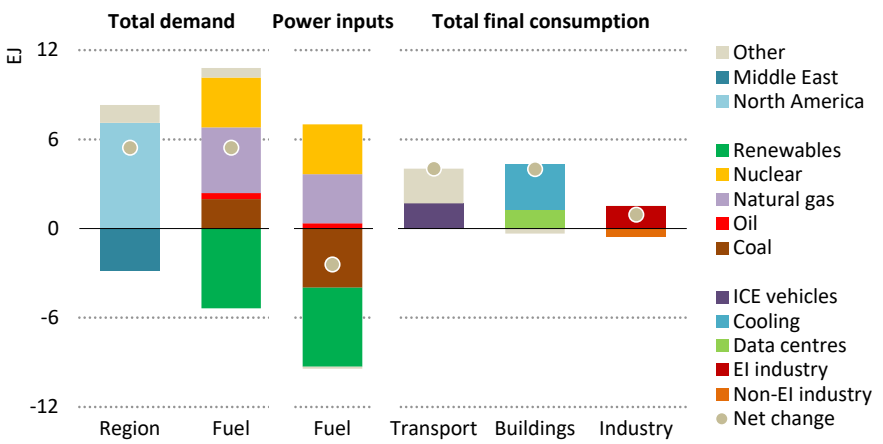
revisions to energy demand is that for the Middle East, where adjustments in the rate of GDP growth due to conflict have contributed. The overall reduction in demand is more than offset by higher demand from some other regions, including Central and South America, Southeast Asia and the United States.

Figure 3.3 ▷ Differences in global energy demand in 2035 in the *WEO-2026* CPS relative to the *WEO-2025* CPS



Total energy demand in 2035 in WEO-2026 is higher than in WEO-2025; cooling is one of the largest contributors to upward revisions

Note: EI = energy-intensive; ICE = internal combustion engine.

In the *World Energy Outlook 2026* (*WEO-2026*), the CPS notably sees more demand for nuclear energy in 2035 than in *WEO-2025*, reflecting firmer policy support. Natural gas demand is also higher. Coal demand is revised upwards as some countries such as India, Japan and Korea use more for power generation. Total 2035 energy demand for power generation in the CPS is 2 EJ lower than in *WEO-2025*, partly due to a methodological update to assign curtailment to specific renewable sources and exclude it from reported electricity generation (see Annex A); without the change, renewables would be within 6% of the *WEO-2025* CPS results in 2035. Oil demand is 1 million barrels per day (mb/d) higher in 2035 in this year's CPS, reflecting an upward revision in demand from road transport in the United States and from buildings, especially for cooking, in emerging market and developing economies. In end-use sectors, the *WEO-2026* CPS shows higher demand from road vehicles and from space cooling in buildings by 2035 than in *WEO-2025*.

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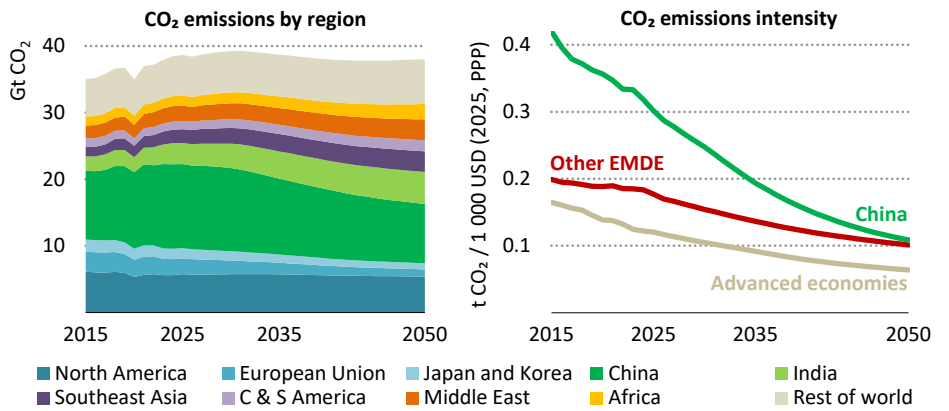
3.2.2 CO_2 emissions

In the CPS, annual global energy-related carbon dioxide (CO_2) emissions remain broadly flat at today's levels through 2050, standing at 38 gigatonnes of carbon dioxide (Gt CO_2) (Figure 3.4). Energy-related methane emissions fall from 150 million tonnes (Mt) today to around 140 Mt in 2035. Taken together, CO_2, methane and other greenhouse gas emissions would lead to a global average surface temperature rise of around 2 degrees Celsius (°C) in 2050 and 2.9 °C in 2100, which is broadly in line with the WEO-2025 CPS.

Figure 3.4 ▷ CO_2 emissions and CO_2 emissions intensity by region in the CPS, 2015-2050



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CO_2 emissions remain broadly flat to 2050, despite substantial reductions in emissions intensity, notably in China

Notes: t = tonne; Gt = gigatonne; CO_2 = carbon dioxide; PPP = purchasing power parity; EMDE = emerging market and developing economies. Rest of world includes international bunkers.

The broad stability in aggregate global CO_2 emissions masks significant regional shifts. The share of global emissions from advanced economies declined from 35% in 2015 to nearly 30% today and falls further to almost 25% by 2035 in the CPS, with the European Union, Japan and Korea leading the way as coal-fired generation declines and energy demand plateaus over the next decade. China's emissions peak before 2030 and undergo the largest absolute reduction, driven by lower coal-fired generation, as its emissions fall by 1.2 Gt by 2035, which is equivalent to around 3% of today's global emissions. CO_2 emissions rise in most other emerging market and developing economies as their populations grow and economies develop. Africa, India and Southeast Asia increase their combined share of global emissions from 17% today to 27% in 2050.

CO_2 emissions intensity decreases across all regions to 2050. The decline in emissions intensity relative to GDP is particularly pronounced in China, where emissions intensity falls by two-thirds by 2050. This reflects the continued rebalancing of China's economy away from

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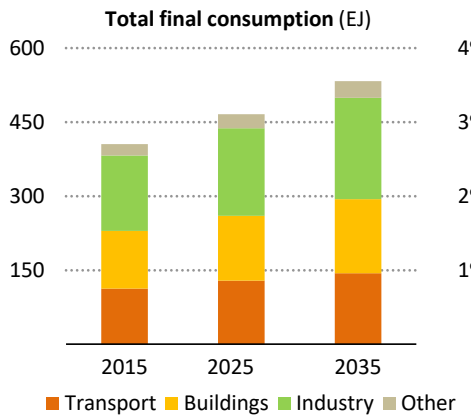
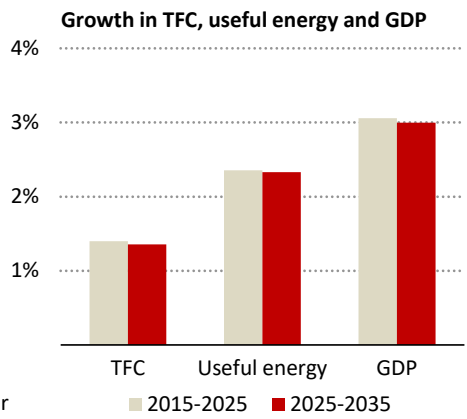
construction-led, energy-intensive industrial growth towards services and higher-value manufacturing, together with growth in renewable generation and the take-up of electric vehicles (EVs). Emissions intensity also falls in other regions by 2050, declining from today's levels by 50% in advanced economies and by 40% in emerging market and developing economies excluding China. In the CPS, however, these improvements do not translate into a rapid decline in absolute global emissions because rising economic activity and growing populations offset much of the reductions from lower-emissions energy sources and more efficient energy use.

3.3 Total final consumption

Total final consumption rose by an average of 1.4% per year over the past decade, reaching a global total of 466 EJ in 2025. It continues to increase in the CPS by around 1.4% per year through to 2035, growing at an annual average rate of 1.5%, 1.3% and 1.1% in the industry, buildings and transport end-use sectors, respectively.

Figure 3.5 ▷ Total final energy consumption and average annual growth of final consumption, useful energy and GDP in the CPS, 2015-2035





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Total final consumption and useful energy consumption continue to grow through to 2035; useful energy grows faster than total final consumption

Notes: GDP = gross domestic product; TFC = total final consumption. Other includes agriculture and other non-energy use. Useful energy is the energy available to end-users to deliver energy services, such as heat from boilers or motion from vehicles, after accounting for conversion losses in end-use technologies.

Useful energy is the energy available to end-users to deliver energy services, such as heat from boilers or motion from vehicles, after accounting for conversion losses in end-use technologies. In the CPS, useful energy continues to grow across all regions (Figure 3.5).

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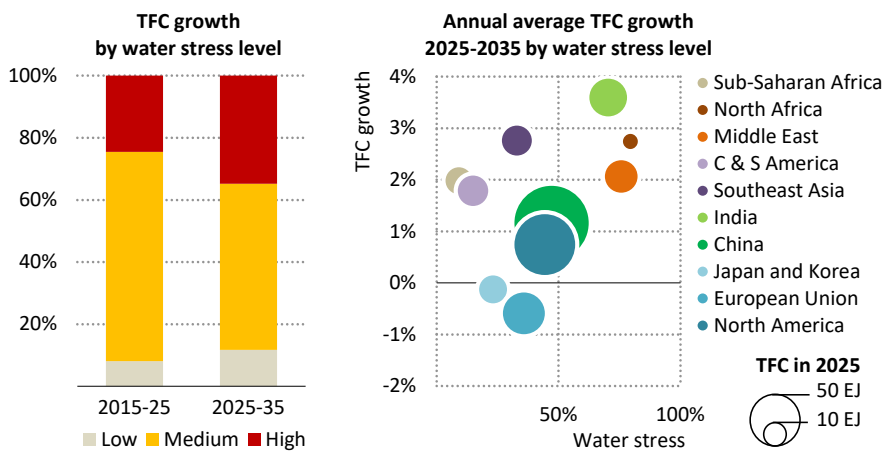
Useful energy grows faster than total final consumption as electrification advances – notably through the rising adoption of EVs, since electric technologies are more efficient than fossil fuel technologies – and as minimum energy performance standards (MEPS) extend their reach.

Box 3.2 ▷ Growing water stress and the impacts on energy

Water stress – measured as the ratio of total water demand to available renewable water supplies – is intensifying, with over 600 million more people exposed to extremely high water stress than two decades ago. The relationship between water and energy runs both ways: energy systems depend on water for cooling thermal power plants and data centres, hydropower and industrial processes, as well as fossil fuel extraction and treatment. Conversely, water supply depends on energy for pumping, treatment and desalination. Growing pressure on freshwater resources can therefore increase energy demand, while water availability directly affects energy supply, particularly hydropower output.

Figure 3.6 ▷ Total final energy consumption growth in the CPS relative to water stress level worldwide and by region, 2015-2035



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With 35% of energy demand growth expected in water-stressed regions over the next decade, effective water management in the energy sector becomes more important

Notes: TFC = total final consumption. Water stress is measured as the ratio of total water demand to available renewable water supplies and weighted by population. Low water stress refers to a ratio below 20%, medium water stress to a ratio between 20% and 60%, and high water stress to a ratio above 60%.

Source: IEA analysis based on WRI (2023).

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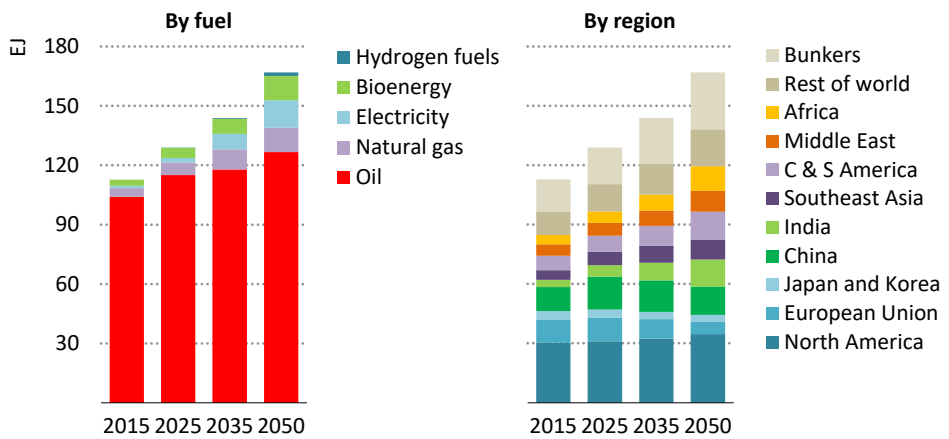
Energy consumption growth is increasingly concentrated in water-stressed regions (Figure 3.6). Over the past decade, 25% of the increase in global final consumption occurred in highly water-stressed areas, and this share rises to 35% over the next decade, driven by growth in India, the Middle East and North Africa.

Although the energy sector accounts for a relatively small share of global water withdrawal, at around 10% (just above 400 billion cubic metres), its share can be much larger locally. Water availability could therefore shape local energy choices. Water intensity and resilience become important considerations in investment decisions, influencing cooling technologies for power plants and data centres, the potential of hydropower systems, and the siting of new industrial facilities. Growing water constraints can therefore affect the cost and resilience of energy infrastructure.

3.3.1 Transport

Transport energy demand increases by more than 10% by 2035 in the CPS. It declines by 2% in advanced economies, but it rises by 20% in emerging market and developing economies, with Africa, Central and South America, and India together accounting for around 50% of total transport energy demand growth (Figure 3.7). The rise in energy demand is underpinned by an increase of more than 25% in passenger mobility demand and freight activity growth over the next decade.

Figure 3.7 ▷ Transport energy demand by fuel and by region in the CPS, 2015-2050



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Transport energy demand grows across most regions as declines in advanced economies are offset by growth of 20% in emerging market and developing economies

Notes: Hydrogen fuels include hydrogen and hydrogen-based fuels. Bunkers include both international aviation and marine bunkers.

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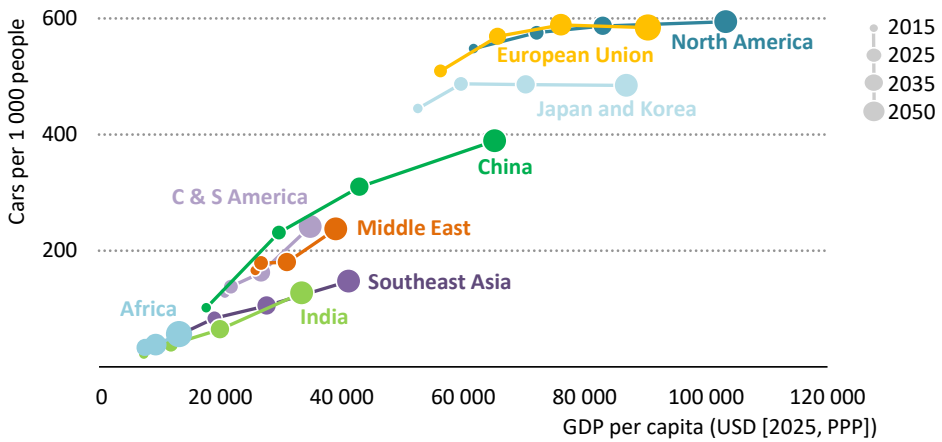
Oil continues to dominate the transport energy mix, although its share, 89% in 2025, falls in the CPS by seven percentage points by 2035 as electricity and bioenergy demand rises. Electricity demand rises as EV deployment expands, particularly in China, the European Union, the United Kingdom, and Southeast Asia. Growth in liquid biofuels is supported by blending and volume mandates, tax incentives and low-carbon fuel standards in a number of regions and countries, including Brazil, Canada, the European Union, India, Indonesia and the United States.

Figure 3.8 ▷ Car ownership and GDP per capita by key region in the CPS, 2015-2050



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Many advanced economies approach a ceiling in car ownership, but ownership grows rapidly in emerging market and developing economies as incomes rise

Passenger cars today account for nearly 60% of land-based passenger mobility activity, and this share remains broadly unchanged over the coming decade. In advanced economies, where on average one in two people already own a car, markets are approaching saturation (Figure 3.8). Urbanisation, expanding public transport and demographic trends dampen demand, and car ownership levels decline slightly in some countries, including Japan. Mobility demand is higher in the United States than in other advanced economies, and its car ownership rate rises to around 750 cars per 1 000 people by 2050. This reflects a combination of factors, including low urban density, extensive suburban development and consumer preferences. Car ownership is much lower in emerging market and developing economies; only around one in ten people own a car today, but rising incomes boost this to around one in six people by 2050. By then, car ownership in China is not far behind its level in Japan and Korea, while ownership also rises rapidly in India and across Central and South America and Southeast Asia.

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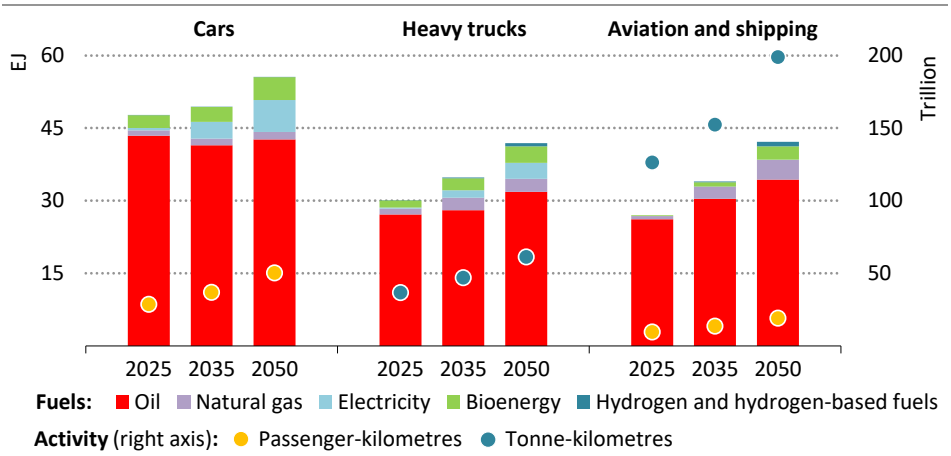
Although the global passenger car fleet expands by nearly 20% by 2035, road transport energy use rises by 8%, reflecting some efficiency gains and moderate EV sales. Progress is slower than in the past because the CPS assumes that fuel economy standards are not strengthened beyond policies already in place and that EV growth takes place primarily in China, the European Union and Southeast Asia. The EV share of new car sales rises from around 25% in 2025 and reaches nearly 50% in 2035. By then, more than 90% of new car sales are electric in China and the European Union. However, policy support and charging infrastructure are weaker elsewhere, keeping EV sales near their current levels through 2050. The take-up of electric heavy trucks, including medium freight and heavy freight trucks, is led by China, where the technology is already cost-competitive in certain applications and sales took a market share of over 25% in 2025. Electric heavy trucks account for around one-fifth of global truck sales by 2035 in the CPS.

Figure 3.9 ▷ Energy demand and activity by selected transport modes and fuel in the CPS, 2025-2050



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Passenger and freight transport activity grows, driving energy demand growth across all fuel types

Aviation activity rises by 40% over the decade to 2035, making aviation the fastest-growing mode of the transport sector in the CPS. This lifts aviation oil demand from around 7.5 mb/d today to over 9 mb/d, which is equivalent to the current total oil demand of the European Union. Shipping activity increases by over 20% by 2035, but modest efficiency gains and fuel switching moderate growth in oil demand from this sector. Although oil demand rises to around 5.5 mb/d, its share of shipping fuels falls from around 92% in 2025 to 81% in 2035, while LNG's share rises to 17%. Passenger and freight rail activity increase by around 35% and nearly 15%, respectively. Despite a modest increase in electrification in emerging market and developing economies, global rail oil demand rises slightly, reaching around 0.65 mb/d by 2035 (Figure 3.9).

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Continued investment in charging infrastructure, together with associated investments in timely grid connections, distribution network reinforcement and smart charging, remains a critical enabler of transport electrification. In the CPS, investment is limited, particularly in emerging market and developing economies outside China. This remains one of the key barriers to faster electrification.

Used car imports are another factor shaping transport energy trends (Box 3.3). Used car imports today account for around 7% of global car registrations. In the CPS, the pace of efficiency gains for conventional cars slows to 0.4% annually over the period to 2035, compared to 0.6% over the previous two decades. Future oil demand trends will also depend on the origin of these vehicles, the pace at which exporting countries electrify their vehicle fleets, and how quickly imported vehicles transition away from oil consumption.

Box 3.3 ▷ The role of used car imports in shaping future trends

Around 60 million cars are retired from the primary market every year. Most of these cars are scrapped or recycled, but around 10% are exported as used vehicles. Advanced economies and China remain the main sources of used cars for export, the majority of which are exported to emerging market and developing economies outside China (Figure 3.10). In the CPS, used car import volumes increase by around 50% from today's level by 2035, in line with passenger car demand growth in the main importing regions. Most imports by 2035 are directed to Africa, Eurasia and the Middle East, and these regions together account for around half of global imported used cars.

The growing used car trade increasingly shapes fleet efficiency and electrification in emerging market and developing economies outside China, while helping to meet the demand for car ownership in these regions. As China and the European Union electrify their fleets, used EV exports are set to provide an important source of electric cars for developing economies. In the CPS, used electric car exports rise to 300 000 by 2035, improving fuel economy in importing countries by 10% compared with today. By 2050, used car imports in emerging market and developing economies outside China are twice as electrified as new car registrations, reflecting the high proportion of EVs in vehicle fleets in major exporters of used cars, such as China, the European Union, Korea and the United Kingdom. At the same time, used hybrid cars can deliver efficiency improvements where charging infrastructure and grids are less developed.

The international trade in used cars can help to pass on improvements in fuel economy and electrification to importing regions, but it may prolong the use of inefficient cars by shifting models that no longer meet efficiency or pollutant standards in exporting regions to markets with less stringent regulations. Moreover, as used EV exports reach their end of life in secondary markets, more EVs will need to be scrapped in countries that today do not have established systems for domestic battery recycling and critical mineral recovery. Those countries will need to develop such systems (IEA, 2024). The climate benefits of used EV imports, meanwhile, depend on the sources of power generation in

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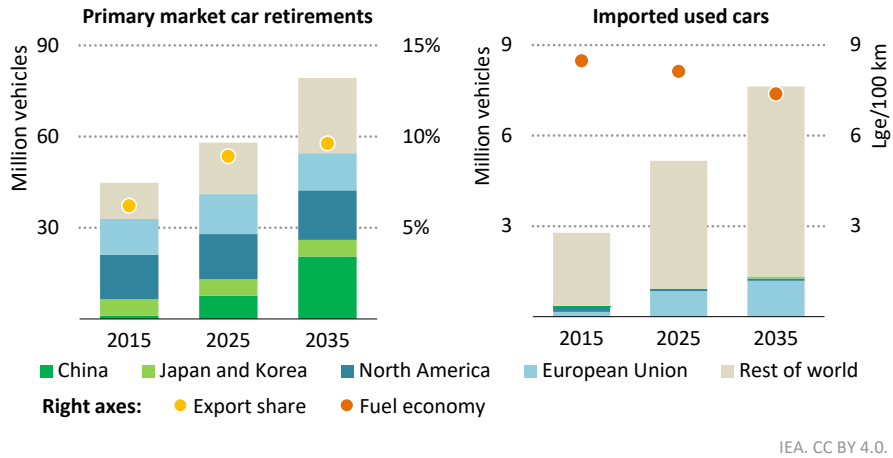
importing countries: in the CPS, electricity emissions intensity in emerging market and developing economies outside China falls by 25% by 2035, a smaller decline than the global average.

Figure 3.10 ▷ Primary market car retirements by main export region and their export share, and imported used cars and their fuel economy by selected region in the CPS, 2015-2035



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Growing used car exports from electrifying markets such as China and the European Union extend efficiency improvements and EV penetration in developing economies

Notes: Lge = litre of gasoline equivalent; km = kilometre. Analysis excludes intra-EU used car trade volumes. Primary market car retirements are cars that have reached the end of life in the primary market and are either scrapped or exported to a secondary market.

3.3.2 Buildings

Energy consumption in the buildings sector has increased by 1.1% per year since 2015, with rapid growth in demand for energy services outweighing savings from efficiency, electrification and switching away from the traditional use of biomass. In the CPS, the demand for energy services in buildings continues to grow, but MEPS and building energy codes are not strengthened beyond their current levels. Market shares of more efficient appliances, such as heat pumps, remain constant to 2050, except in markets where they are already cost-competitive without government subsidies. As a result, efficiency gains, heating and cooking electrification, and the rate at which access to modern energy expands all level off, and energy consumption grows by 1.3% per year to 2035.

In advanced economies, consumption rises in the CPS by an annual average of 0.5% through to 2035 after being broadly flat over the last ten years. This change reflects the rise of artificial intelligence (AI) and data centre electricity consumption, notably in the United States, as well as slower efficiency improvements in appliances, equipment and building

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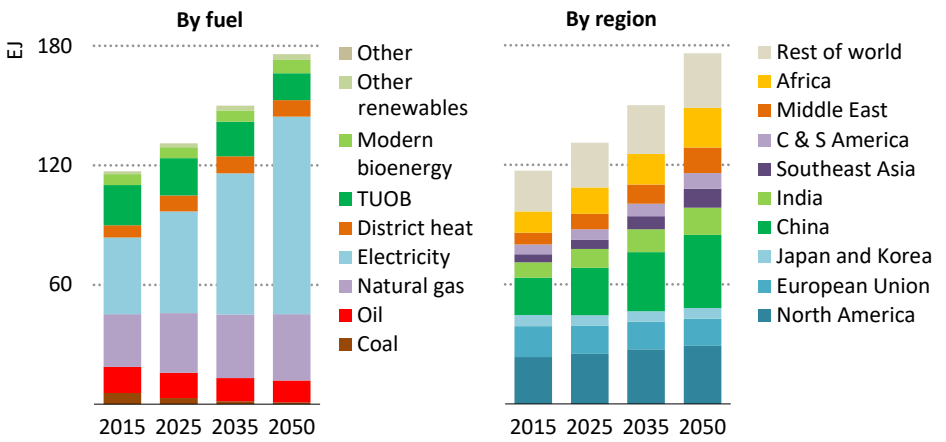
envelopes (Figure 3.11). Consumption in China grows at broadly the same rate as in the last decade. It rises by almost 6 EJ by 2035, even though China adds less floorspace than in the previous decade; limited efficiency gains do not offset higher appliance utilisation rates as incomes grow.

Figure 3.11 ▷ Buildings energy demand by fuel and region in the CPS, 2015-2050



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Demand grows in almost all regions, rising fastest in EMDE; electricity use increases 40% by 2035, and fossil fuel demand remains flat in aggregate

Notes: TUOB = traditional use of biomass. Other renewables include solar thermal and geothermal. Other includes non-renewable waste and hydrogen. Buildings sector includes energy consumption for data centres and desalination.

In other emerging market and developing economies, population growth, higher incomes and rising temperatures raise residential demand drivers, with floorspace expanding by 25 billion square metres, appliance stock growing by 1.2 billion units and air conditioner stock more than doubling by 2035 (Figure 3.12). Consumption by the buildings sector in India and the Middle East increases by around 2% per year, and Southeast Asia sees consumption growth accelerate from an annual average of 1.5% in the last decade to 3.5% in the next ten years. In countries where a significant share of the population relies on the traditional use of biomass, notably in Africa, the stock of cookstoves grows faster than the number of households as the rate of access to clean cooking solutions rises. In aggregate, emerging market and developing economies make up more than 85% of global demand growth for buildings.

Over the past decade, buildings demand for oil and coal decreased by an annual average of 0.2% and 5.9%, respectively, as demand shifted to other fuels. Demand for natural gas grew by 1.3% per year, and demand for electricity and district heat increased at more than twice

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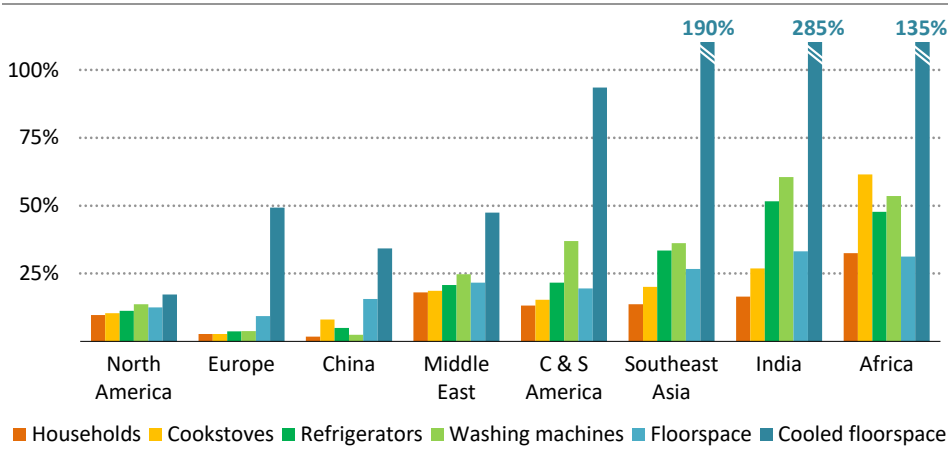
this rate. The outlook for the coming decade is shaped in the CPS by the assumption that there is no increase in retrofit rates, no further strengthening of mandatory building energy codes and no new gains from voluntary schemes. A further assumption is that current subsidies are not renewed when they reach their expiration date, so that sales of electric equipment such as heat pumps grow only in markets where those technologies are cost-competitive without government fiscal support.

Figure 3.12 ▷ Change in key demand drivers in the CPS between 2025 and 2035



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Floorspace, household and appliance stocks grow in all regions, with growth concentrated in EMDE and space cooling

Note: Cookstoves include only households with access to clean cooking.

Electricity demand growth from buildings accelerates to 3.3% per year, adding 5 500 terawatt-hours (TWh) to annual demand by 2035. Of the electricity demand growth, 85% comes from higher consumption in electric-only end-uses such as cooling, appliances and data centres. By 2035, energy demand from data centres reaches a level comparable to that of lighting today (Box 3.5). Heating and cooking electrification advances in the CPS at around the same pace as during the past decade. The share of electricity in heating and cooking rises slightly from 15% today to 17% by 2035, despite the emphasis on the secure supply of cooking fuels during the 2026 energy crisis and the surge in sales of induction cookstoves (notably in India).

Natural gas demand in buildings grows by 0.7% per year and reaches 920 billion cubic metres (bcm) by 2035; a slight decrease in demand in advanced economies of 0.4% per year is outweighed by rising demand in emerging market and developing economies of 2% per year. The use of natural gas in buildings in emerging market and developing economies expands in China in particular, where space heating demand supports network expansion. Natural gas

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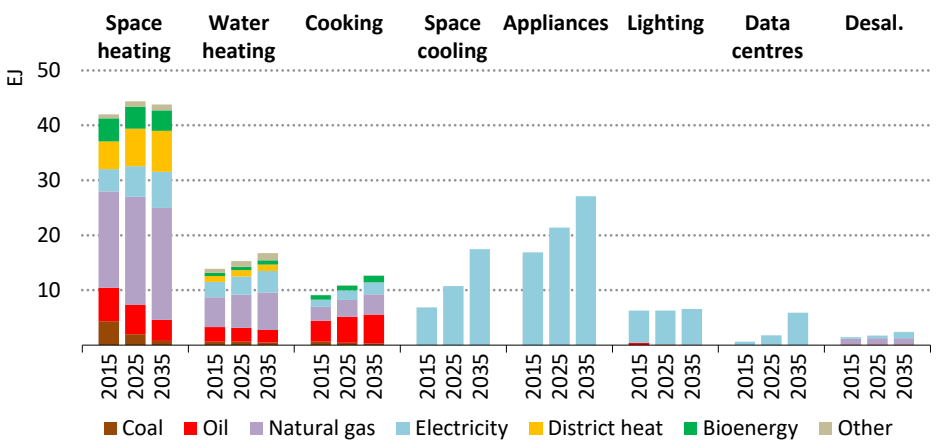
meets almost 20% of China's space heating needs by 2035 – double its share in 2015. Natural gas demand for buildings also expands in India, where policies support piped natural gas for cooking in urban areas as an alternative to liquefied petroleum gas (LPG), and, to a lesser extent, in Eurasia, which already has a relatively high share of gas use in buildings. Other emerging market and developing economies, notably in Southeast Asia, lack the space heating requirements to justify large-scale capital investments in gas distribution infrastructure across the region. Only a few large cities across Indonesia, Malaysia and Singapore have networks today, and country plans for network development remain limited.

Figure 3.13 ▷ Energy demand in buildings by end-use and by fuel in the CPS, 2015-2035



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Space heating is the largest end-use in buildings, with an electrification rate of almost 15%; cooling and appliances demand sees the largest growth by 2035

Notes: Desal. = desalination. This split excludes traditional use of biomass, which is not allocated to any end-use specifically. Other includes solar thermal, geothermal, non-renewable waste and hydrogen.

Space heating accounts for around one-third of buildings demand, making it the biggest end-use of energy in the buildings sector (Figure 3.13). Globally, water heating and cooking account for around 12% and 8% of buildings demand, respectively, but they have a larger share in regions with limited heating needs. Consumption in these three end-uses remains relatively stable at around 70 EJ through 2035. End-uses that allow for multiple energy sources account for 55% of buildings demand, and their share drops to 50% by 2035. This is a result of electric-only end-uses, such as appliances and cooling, growing the most: these account for 90% of total buildings energy demand growth to 2035. Cooling demand is growing particularly fast: it has increased by 55% since 2015, and it is set to grow by a further 60% in the next decade. Globally, there is less cooling than heating demand, but more electric cooling than electric heating demand.

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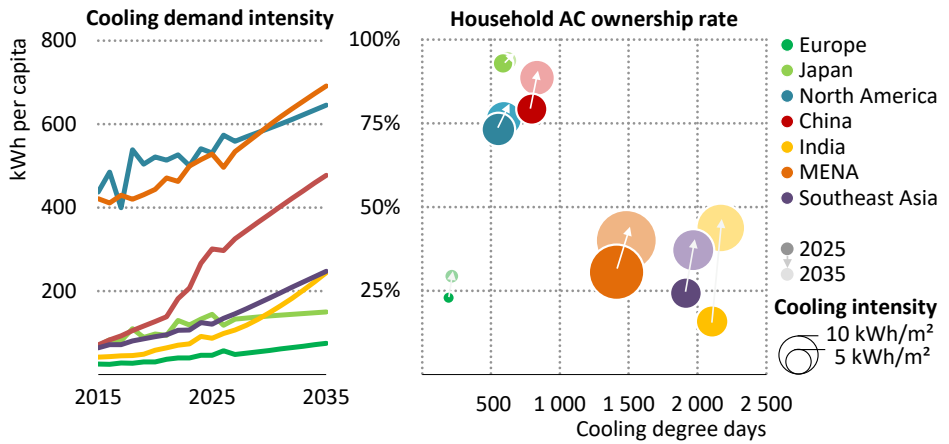
Today, around 80% of the global population lives in places with cooling needs for at least a part of the year, but only around 40% of households own an air conditioner (AC). Access to cooling equipment is also unevenly distributed: some of the warmest countries in the world are emerging market and developing economies with relatively low shares of AC ownership, indicating a significant unmet need for cooling (Figure 3.14). As incomes and temperatures rise, more households are acquiring air conditioners, and around half of all households globally are set to own an air conditioner by 2035. At the same time, AC-owning households add more units, increasing the global stock of air conditioners. Over 85% of the increase in the global residential AC stock in this period takes place in emerging market and developing economies.

Figure 3.14 ▷ Residential cooling demand intensity and AC ownership against cooling degree days in the CPS, 2015-2035



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Regions with the highest cooling needs tend to have low ownership rates, but ownership rises with income and temperatures, pushing cooling demand intensities higher

Notes: kWh = kilowatt-hour; AC = air conditioner; MENA = Middle East and North Africa. Bubble size reflects the average cooling consumption per square metre in the region. Cooling degree days are a measure of cooling needs, quantifying how much local temperatures exceed a threshold temperature (21 °C) over the year.

Hotter weather and higher incomes lengthen the time that the increasing stock of ACs is used each year by consumers. This longer use drives up cooling demand intensity. In the CPS, MEPS remain at their current levels, slowing improvements in AC efficiency to 2035 relative to the past decade and contributing to higher cooling demand intensity. As a result, cooling demand increases from 3 000 TWh today to 4 900 TWh by 2035, with major implications for peak electricity demand and power system infrastructure (see Section 7.4).

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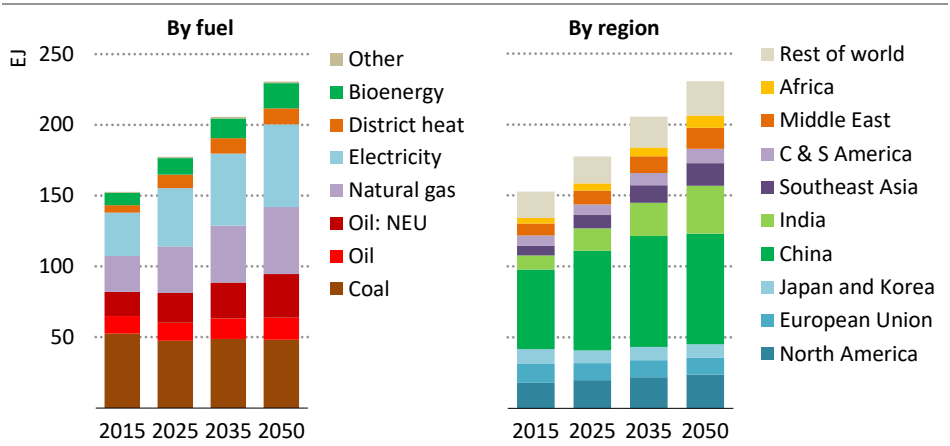
3.3.3 Industry

Energy demand in industry has increased by an average of 1.5% per year over the past decade, with demand growth for steel, chemicals and other industrial products outstripping material and energy efficiency gains. In the CPS, similar trends continue: recycling rates for plastics and scrap shares in aluminium production increase only modestly over the next decade, electrification proceeds at a pace broadly in line with historical trends, and energy efficiency investments occur only where they have a short payback period. Project funding is assumed to be disbursed only where it has already been committed. As a result, energy demand from industry grows by an average of 1.5% per year over the next decade.

Nearly all industrial energy demand growth over the past decade was concentrated in emerging market and developing economies, where industrial energy consumption grew by 2.2% per year, with China and India alone accounting for nearly 80% of the increase (Figure 3.15). Over the next decade, the geographic spread of demand growth broadens in the CPS. China and India still account for most industrial energy demand growth, but their share of the increase declines to 55% as growth accelerates elsewhere, with industrial energy demand in every other region increasing faster than it did over the previous decade. In emerging market and developing economies, industrial energy demand grows at an average annual rate of 1.8% to 2035, while in advanced economies, it rises by an average of 0.7% per year.

Figure 3.15 ▷ Industry energy demand by fuel and by region in the CPS, 2015-2050



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Coal demand flattens, while oil demand accelerates, supported by petrochemicals, with more than 50% of chemical production growth occurring in China

Notes: 'Other' fuels include hydrogen, non-renewable waste, solar thermal and geothermal. Non-energy use (NEU) is only shown separately for oil. Electrolytic hydrogen produced on site is reported as electricity.

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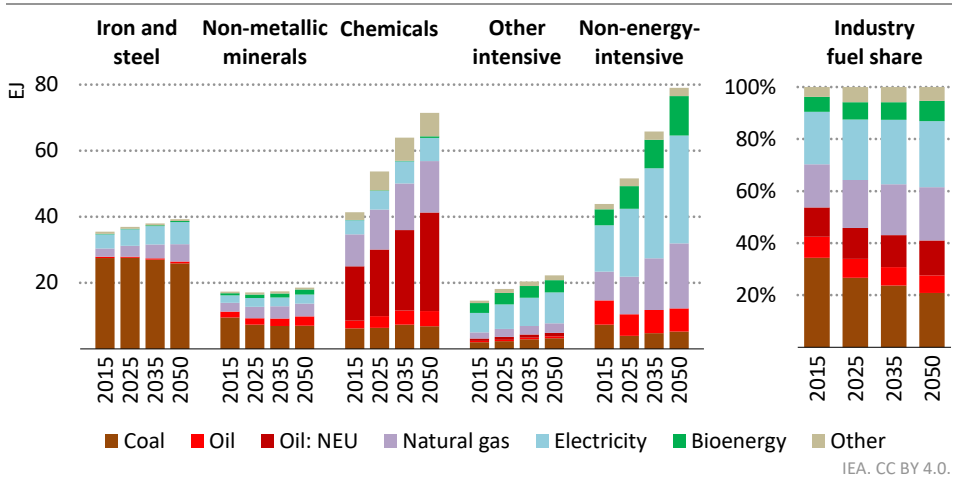
Industrial oil demand rises by roughly 3.8 mb/d over the next decade, which translates into an average annual increase of around 1.8%. This growth is driven mainly by petrochemicals, for which oil is used as a feedstock. Petrochemical feedstocks account for three-quarters of total industrial oil demand growth. The share of petrochemical feedstocks in global oil demand rises from 13% today to 15% in 2035, reflecting comparatively fast-growing demand for oil-based inputs used to produce plastics, packaging and synthetic fibres embedded in a wide range of consumer and manufactured products. Industrial natural gas demand increases by nearly one-quarter to 2035, and its share in industrial demand edges up from 18% to 20%, while non-energy use of natural gas increases by nearly 20%.

Industrial coal demand remains broadly flat at the global level to 2035, but this masks important regional differences. In China, the sector's coal demand continues to decline, falling by nearly 15% over the next decade, supported by tighter coal consumption benchmarks and measures under the 15th Five-Year Plan to retire or upgrade inefficient iron and steel capacity. By contrast, demand rises in other emerging market and developing economies, particularly in India and Southeast Asia, where it grows by 55% and 34%, respectively. Coal use in the chemicals sector becomes an increasingly important element of overall industrial coal demand, rising by 15% in China and more than doubling from a low base in India over the next decade.

Figure 3.16 ▷ Industry energy demand by fuel and sub-sector in the CPS, 2015-2050



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Chemicals and non-energy-intensive industries drive more than 85% of industrial energy demand growth over the next decade

Notes: Other intensive = non-ferrous metals and pulp and paper. 'Other' fuels include district heat, hydrogen, non-renewable waste, solar thermal and geothermal. Non-energy use is only shown separately for oil. Electrolytic hydrogen produced on site is reported as electricity.

Industrial electricity demand also grows both in absolute terms and as a share of industrial energy use (Figure 3.16). This reflects rapid demand growth in non-energy-intensive

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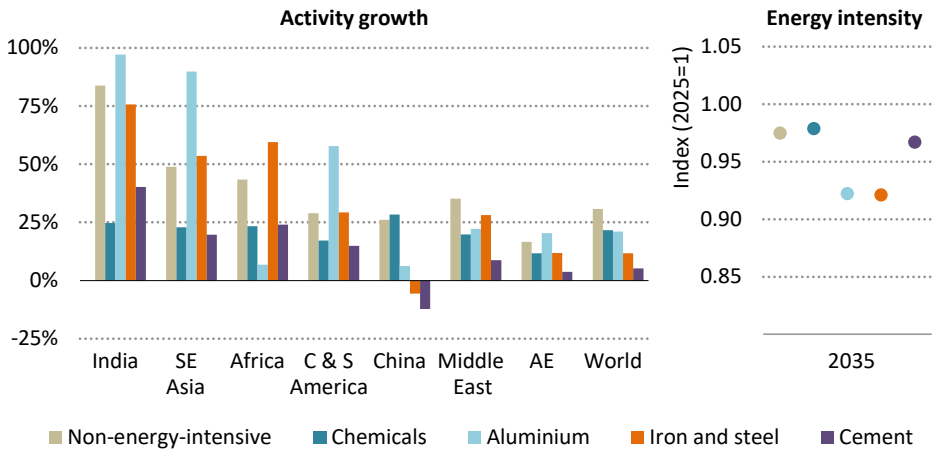
industries such as food, machinery and textiles, in which mechanical energy accounts for a larger share of demand and is provided mainly by electric motors. Low- and medium-temperature heat demand (under 400 °C), which represents nearly 90% of heat demand in non-energy-intensive industries, is also technically well suited to electrification through electric boilers and heat pumps. However, these technologies are adopted in the CPS only where they are cost-competitive, taking into account subsidies and other policy incentives where they exist.

Figure 3.17 ▷ Industrial production growth by region and global energy intensity by industry sub-sector in the CPS, 2025-2035



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Industrial production growth and slow energy intensity improvements push industrial energy demand higher in the CPS

Notes: AE = advanced economies; SE Asia = Southeast Asia. Energy intensity is calculated as sectoral final consumption divided by industrial material production, e.g. primary chemicals for the chemicals sector or by industry value added (PPP) for non-energy-intensive industries.

Rising industrial energy demand in the CPS is driven by continued growth in activity across all industry sectors, which is partially offset by modest improvements in energy efficiency (Figure 3.17). Non-energy-intensive industries see the largest increase in energy demand over the coming decade, particularly in the food and tobacco and machinery sub-sectors in India and Southeast Asia. Chemicals see stronger growth in both absolute and relative terms than any other energy-intensive sector, supported by robust demand for petrochemicals, which is largely driven by economic growth in emerging market and developing economies. Primary chemicals production increases by over 20% to 2035, with emerging market and developing economies accounting for 85% of the increase, and China alone for more than 50%. Emerging market and developing economies also account for nearly 90% of growth in cement production over the coming decade and for roughly 80% of growth in aluminium and steel production. Industrial energy demand grows much more slowly in advanced

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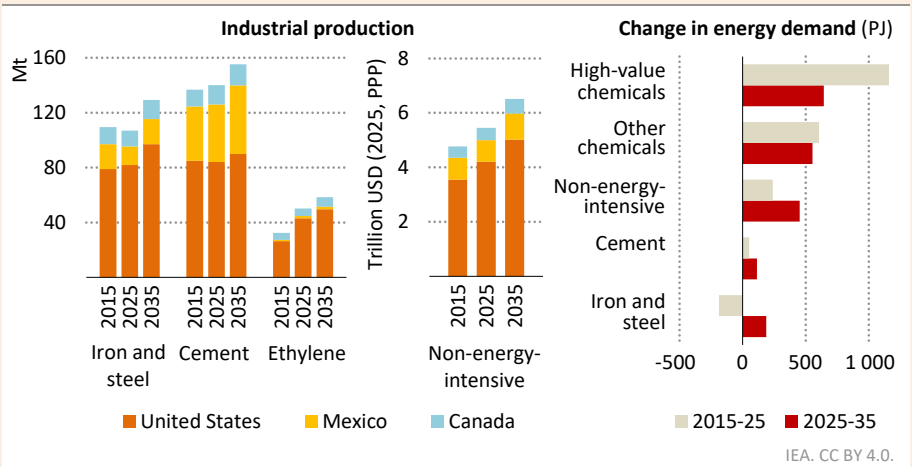
economies, but many of them also see a rebound in industrial production growth over the next decade, reversing the previous decade's trend of negative aggregate growth (Box 3.4).

Energy intensity improves relatively slowly in the CPS over the next decade, but gains are still made through a mix of technological innovation and existing government measures. Advances in digitalisation and AI contribute to these gains by supporting process optimisation and innovation across sectors (IEA, 2026a). Policy frameworks already in place (such as China's 15th Five-Year Plan, Japan's 7th Strategic Energy Plan or Korea's 11th Basic Plan for Electricity Supply and Demand) help drive efficiency gains in industry through energy intensity improvement targets and MEPS. The iron and steel and aluminium sectors see the strongest improvements in energy intensity as growing scrap availability increases the share of less energy-intensive secondary production. Globally, industrial energy intensity improves by 1.2% per year to 2035, slightly above the pace of improvement over the previous decade.

Box 3.4 ▷ North America's industrial rebound gathers pace

Since the late 20th century, industrial activity has increasingly shifted from advanced economies towards emerging market and developing economies. In North America, industrial energy demand peaked in 2000 and stood roughly 15% below that level in 2015. This trend has begun to reverse, with demand increasing by around 10% over the past decade. The recovery in industrial activity is projected to continue and, in the CPS, this results in industrial energy demand in North America rising by a further 11% by 2035 (Figure 3.18).

Figure 3.18 ▷ Industrial material production and change in energy demand by industry sub-sector in North America in the CPS, 2015-2035



North America sees renewed industrial growth, led by chemicals, steel and cement

Notes: PJ = petajoule; Mt = million tonnes. High-value chemicals include ethylene, propylene and aromatics. Other chemicals are ammonia and methanol.

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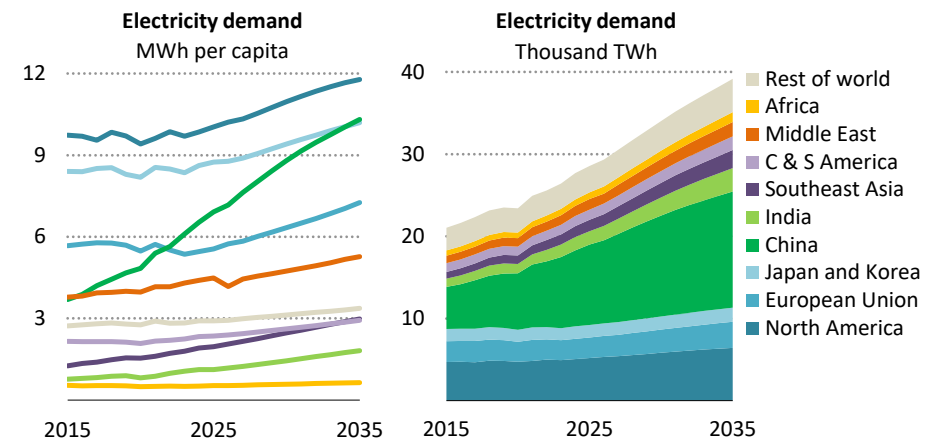
Industrial growth in North America is led by the United States, where investment in the construction of new manufacturing facilities has nearly tripled since 2015 (United States Census Bureau, 2025). Much of this investment is concentrated in high-tech manufacturing and data centres, whose construction supports demand for steel, cement and other industrial materials. In North America, steel production grows by 20%, and output in non-energy-intensive industries and ethylene production by more than 15% by 2035. This industrial growth in the United States reflects a combination of structural advantages and policy support. As the world's largest producer of both oil and natural gas, the United States benefits from an abundant feedstock supply for chemical production and from relatively low fuel and electricity prices among advanced economies for energy-intensive industries. Targeted industrial policy, alongside trade policies that favour domestic manufacturing, further supports industrial expansion.

3.4 Electricity

3.4.1 Demand

Global electricity demand grew by 3% per year over the past decade, outpacing growth in total energy demand. This growth was highly uneven across regions, with demand rising by less than 1% annually in advanced economies and by 5% per year in emerging market and developing economies. China alone accounted for 60% of global growth, nearly doubling its electricity demand, while India and Southeast Asia also saw sustained increases from lower levels.

Figure 3.19 ▷ Electricity demand by region in the CPS, 2015-2035



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Electricity demand grows in all regions, with the strongest contribution to growth coming from emerging market and developing economies

Note: MWh = megawatt-hour; TWh = terawatt-hour.

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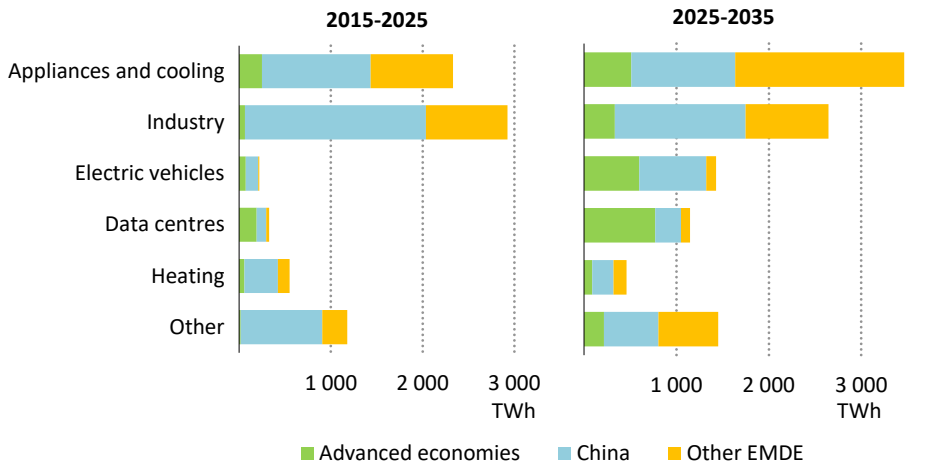
In the CPS, global electricity demand grows by around 3% annually through to 2035, rising by more than 10 000 TWh to 39 000 TWh, up from 28 500 TWh today (Figure 3.19). Demand rebounds in advanced economies, increasing by just above 2% annually, or by around 250 TWh per year, driven by growth from new demand drivers such as data centres and AI, and transport electrification, while efficiency gains in appliances, cooling and industry temper the pace of demand growth. China's electricity demand continues to grow rapidly, reaching 10 megawatt-hours (MWh) per capita by 2035, similar to the level in Japan and Korea in 2035. Other emerging market and developing economies also account for a rising share of demand growth, notably India and Southeast Asia, where electricity demand per capita increases by 5% and 4% per year, respectively. Despite this growth, electricity demand per capita in emerging market and developing economies outside China in 2035 remains 4.5 times lower than the average in advanced economies and nearly 6 times lower than in North America.

Figure 3.20 ▷ Electricity demand growth by end-use and by region in the CPS, 2015-2035



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Deployment of electric appliances and cooling in buildings, and deployment of EVs in advanced economies and China are key drivers of electricity demand growth

Notes: Heating = space and water heating. Other includes other buildings sector, non-road transport, agriculture, and transformation sectors (e.g. petroleum refineries or electrolytic merchant hydrogen production but excluding any own use for electricity generation and distribution losses).

The sectoral drivers of demand growth also change in the CPS (Figure 3.20). As the global stock of residential air conditioners grow from 1.7 billion in 2025 to 2.4 billion in 2035, appliances and cooling in buildings become the largest source of additional global electricity demand, with an increase of 3 500 TWh over the next decade. This growth is a third higher

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than the increase in industrial electricity demand, which was the largest driver of electricity consumption over the past decade. EVs and data centres, while starting from a smaller base, become increasingly important new sources of demand: together they account for a quarter of electricity demand growth over the next decade, up from 7% over the past decade.

In advanced economies, driven by North America, AI infrastructure and data centres become the largest source of electricity demand growth. Transport electrification continues to gain ground in the European Union, where EVs account for half of demand growth. In China, the contribution of buildings rises to 40% of the electricity demand growth over the next decade, with large increases from appliances and cooling. Industry accounts for around 30%, down from 40% during the previous decade, while transport is responsible for close to 20% to 2035, with rapid transport electrification adding 750 TWh to electricity demand. In other emerging market and developing economies, demographic expansion, urbanisation and rising incomes have already lifted buildings electricity demand growth above that of industry since 2015. Further adoption of appliances and air conditioners adds 1 800 TWh of electricity demand to 2035. As the CPS assumes that MEPS are not strengthened beyond their current levels, efficiency gains in buildings and industry are limited and do not fully offset rising demand from appliances, cooling needs and industrial activity.

Box 3.5 ▷ Rising data centre demand: the emerging bottlenecks

Today, electricity demand from data centres and AI amounts to just under 500 TWh (Figure 3.21), equivalent to 1.7% of global electricity demand, but it is growing rapidly. Demand from the sector is on course to double by 2030, and AI-related energy consumption is set to make up around half of the sector's consumption by then. The United States is expected to account for around half of the global market for data centres by 2030 in the CPS, adding around 350 TWh of demand to today's 200 TWh. As a result of this rapid growth, data centres account for over 10% of total US electricity demand by 2030.

The sector is heavily concentrated in a few key markets, mainly the United States, Europe, and China, but demand is now also rising significantly in growing markets such as Southeast Asia. The speed of the global increase is creating bottlenecks. On the energy side, waiting times are increasing for critical grid and power generation equipment such as transformers or gas turbines, and equipment prices are rising. Constraints are also emerging on the information technology side, as emphasised by the 2025 shortage of memory chips, a key hardware component. The data centre demand outlook is increasingly shaped by ever-larger projects, so the confirmation, cancellation or delay of just a few projects could materially alter the overall trajectory.

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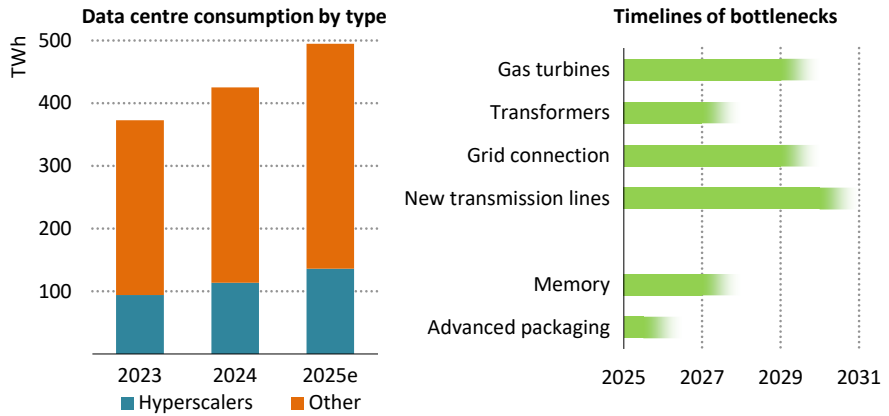
Figure 3.21 ▷ Electricity consumption by hyperscalers and all data centres, and estimated timelines for supply chain bottlenecks



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The rapid expansion of data centres is increasingly constrained by physical limitations on construction and power supply

Notes: 2025e = estimated values for 2025; Hyperscalers = Amazon Web Services (AWS), Microsoft, Alphabet and Meta. Other refers to all other service providers, colocation and enterprise data centres. AWS's data centre electricity demand is derived from water demand figures. Meta electricity consumption data are not available for 2025 at the time of writing. Memory refers to the manufacturing of high-bandwidth memory; advanced packaging refers to the final stage in the chip production process. The length of the bar on the right-hand chart indicates the expected minimum duration of bottlenecks listed.

3.4.2 Electricity generation

The global electricity mix continues to evolve in the CPS, driven by existing policy frameworks, mature technologies and market dynamics. Today's power system remains dominated by coal and natural gas, which together provide 55% of global electricity generation. However, this balance shifts over the outlook period. Generation from coal, the largest source of electricity today, reaches a peak before 2030 and steadily declines thereafter; its share of generation falls from more than one-third to less than one-quarter by 2035 (Figure 3.22). Generation from natural gas increases, but it grows more slowly than electricity demand, its share dropping from 22% in 2025 to 17% by 2050. Nuclear power, the second-largest source of low-emissions electricity today behind hydropower, makes a strong comeback: it more than doubles total output by 2050, raising its share to slightly over 10% (Box 3.6).

Renewable sources of electricity rise rapidly in the CPS. Solar photovoltaics (PV) and wind made up 17% of global generation in 2025, up from 4% a decade ago, and they rise to 35% of total generation in 2035. Their expansion is driven by low costs, mature supply chains and widespread policy support. Complemented by steady growth in generation from

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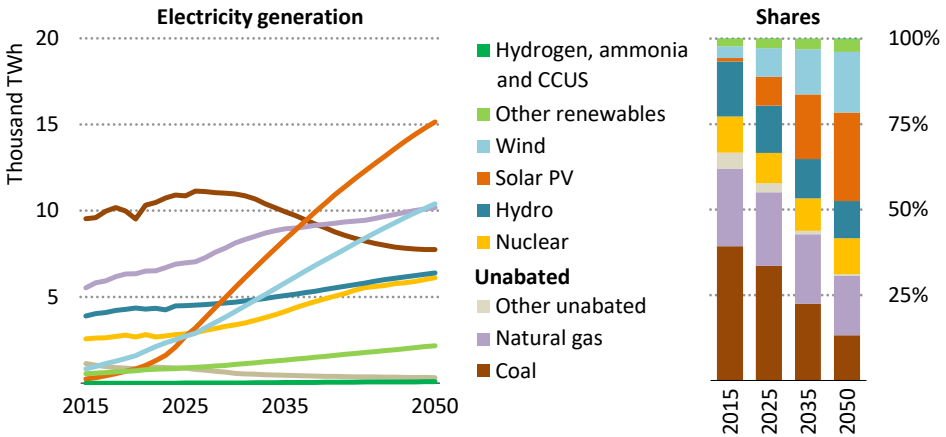
hydropower, bioenergy and geothermal – all of which provide firm low-emissions power – renewables rise from 33% of global generation today to almost 50% by 2035 and close to 60% by 2050.

Figure 3.22 ▷ Global electricity generation by source in the CPS, 2015-2050



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The global generation mix in the CPS shifts towards renewables, with nuclear growth keeping pace with overall demand growth, while coal and oil recede

Notes: PV = photovoltaics; CCUS = carbon capture, utilisation and storage. Other renewables include bioenergy and renewable waste, concentrating solar power, geothermal and marine. Other unabated includes oil and non-renewable waste.

Box 3.6 ▷ The nuclear comeback is underway

Global nuclear generation reached a record high in 2025 and is expected to continue rising. More than 420 gigawatts (GW) of nuclear capacity is currently in operation in over 30 countries. As of July 2026, nearly 90 GW of further capacity was under construction around the world, the highest level in more than 35 years. They are in 17 countries, mostly in China, India, Korea, Russia, Egypt and Türkiye. This includes small modular reactors (SMRs) in Argentina, Canada, China and Russia. Construction started on eight reactors in the first half of 2026, marking one of the highest levels seen in 40 years (Figure 3.23).

Over 50 countries now have plans or targets for nuclear power or have expressed interest in developing new reactors. They include countries in Africa (Egypt, Kenya and Nigeria), Europe (Italy, Poland and Türkiye), the Middle East (Jordan and Saudi Arabia) and Southeast Asia (Indonesia, the Philippines, Thailand and Viet Nam). Many of these countries are particularly interested in SMRs.

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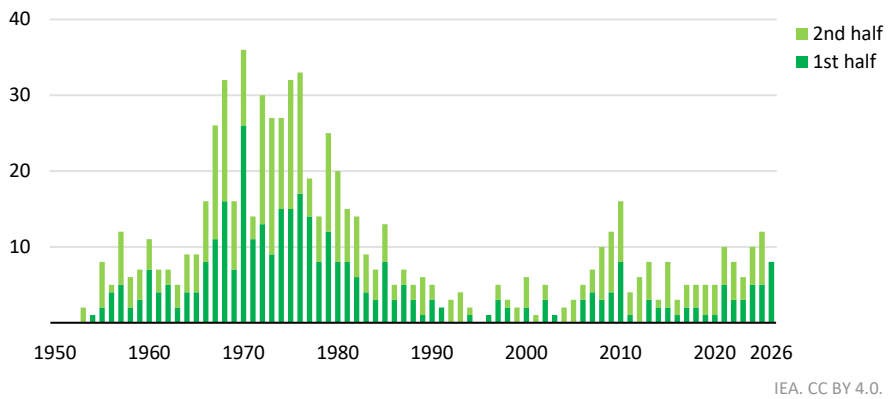
China continues to operate one of the world's largest nuclear construction programmes, while the United States has approved lifetime extensions, allowing several reactors to operate for up to 80 years. In the European Union, nuclear power is increasingly viewed as essential to achieve both energy security and climate goals. Japan is progressively restarting reactors. Activity is progressing in some newcomer countries: new capacity in Bangladesh, Egypt and Türkiye is at an advanced stage of construction, Uzbekistan is starting to build its first nuclear plant, and Viet Nam is moving forward with its first reactor. International backing for nuclear has also strengthened: multilateral development banks are increasingly active in supporting nuclear power, and as of August 2026, 38 countries had endorsed the pledge to triple global nuclear capacity by 2050.

Figure 3.23 ▻ Number of nuclear reactor construction starts by calendar half-year, 1950-2026



Construction started on eight nuclear reactors in the first half of 2026, one of the highest levels in 40 years

Source: IEA analysis based on IAEA PRIS database (2026).

The current geopolitical and energy security environment could further boost nuclear power, which can diversify energy mixes and reduce exposure to market volatility while supporting reliability in increasingly electrified economies. As part of the response to the 2026 energy crisis, many countries have confirmed or strengthened plans for nuclear power or extended the lifetimes of existing reactors, and some are reconsidering restrictions on nuclear development. In addition, new demand drivers, including electrification, AI and data centres, are strengthening the case for firm power sources such as nuclear.

Regional electricity mixes evolve in different ways, reflecting resource endowments, energy security priorities and existing infrastructure (Figure 3.24). While renewables expand almost

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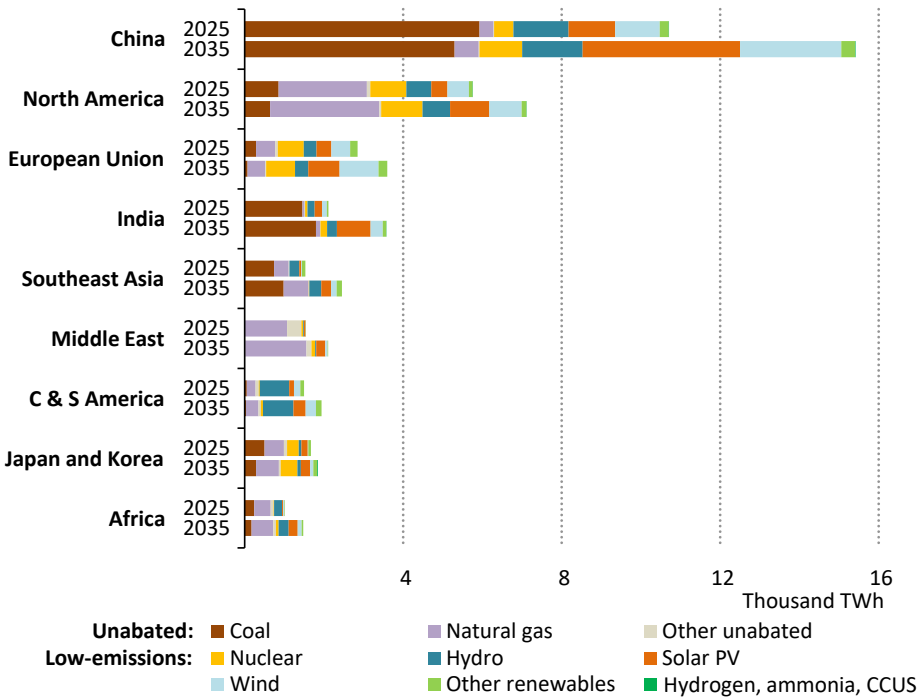
everywhere and nuclear in a growing number of markets, the pace and composition of change differ markedly across regions.

China, India and Southeast Asia continue to have coal-heavy power systems through 2035, but all three regions diversify their mixes as their electricity demand grows faster than in most other parts of the world. Coal remains the largest source in these regions, but wind, solar PV, nuclear power and gas all grow, resulting in more balanced portfolios over time.

Figure 3.24 ▷ Electricity generation by region and source in the CPS, 2025-2035



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Regional electricity mixes remain distinct to 2035, with coal-led regions diversifying, natural gas-led regions holding course and many regions boosting renewables and nuclear

Notes: Other renewables include bioenergy and renewable waste, concentrating solar power, geothermal and marine. Other unabated includes oil and non-renewable waste.

Africa, the Middle East and North America each rely more heavily on domestically available natural gas than other regions. As a result, gas-fired generation remains a cornerstone of their electricity supply in the CPS, although all three regions increasingly complement it with renewables and nuclear power. In the Middle East in particular, diversification helps limit the growth of gas-fired generation, freeing additional gas for export while strengthening electricity security (IEA, 2025).

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The European Union, Japan and Korea are among those regions seeking to reduce dependence on imported fossil fuels by expanding renewables and nuclear power. Natural gas remains important, but its role increasingly shifts towards supporting a system with a larger share of domestic low-emissions generation. Countries in Southeast Asia and other emerging market and developing economies also look to operate existing coal-fired power plants more in the short term to complement renewables and nuclear to help reduce their import exposure while improving energy security and system resilience.

In Central and South America, hydropower is already the backbone of many electricity systems, especially in Brazil. Future growth in electricity generation in the CPS comes primarily from wind and solar PV, supplemented by natural gas to provide flexibility and support reliability during periods of low hydro availability. As a result, the region maintains one of the world's lowest-emissions electricity mixes.

Table 3.1 ▷ Major policies and measures in electricity supply and their combined impact on the outlook for selected regions

Region	Major policy	Combined impact on outlook for:			
		Renewables	Nuclear	Unabated natural gas	Unabated coal
China	15th Five-Year Plan	●	●	●	●
India	National Electricity Plan including transmission expansion, Renewable Purchase Obligations	●	●	●	●
Indonesia	Electricity Supply Business Plan 2025-2034	●	●	●	●
European Union	National Energy and Climate Plans, coal phase-out commitments in 14 member states	●	●	●	●
Japan	7th Strategic Energy Plan	●	●	●	●
Korea	11th Basic Plan for Electricity Supply and Demand	●	●	●	●
United States	The One Big Beautiful Bill Act	●	●	●	●
South Africa	Integrated Resource Plan 2025	●	●	●	●

● Favourable ● Unfavourable ● Neutral

Recent power sector policies and measures across major economies are supporting more diversified electricity mixes and strengthening energy security. Many are implementing measures to expand renewables and nuclear power, while approaches to coal and natural gas differ according to domestic circumstances (Table 3.1). Measures adopted in China, the European Union, Japan, Korea and India strengthen the framework for further renewables growth. China's 2025 power market reforms, for example, mark a shift towards market-

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based mechanisms aimed at sustaining rapid renewables deployment while improving their integration into the power system.

In several fuel-importing countries, short-term measures taken in response to the 2026 energy crisis support coal use in the power sector in order to reduce dependence on imported natural gas. Japan temporarily lifted restrictions on inefficient coal-fired power plants for the 2026 fiscal year, Korea delayed the retirement of selected coal units, and Italy pushed back its planned coal phase-out date. These measures do not alter the broader direction of travel towards lower-emissions electricity systems, but they underline how energy security considerations continue to shape near-term policy choices.

Natural gas is the only fossil fuel in the power sector to grow globally to 2035 in the CPS, returning to growth as recent market disruptions ease and supply expands. Growth is led by regions with large domestic resources, particularly North America and the Middle East. Meanwhile, expanding LNG supply allows importing economies to increase gas use, especially in China and Southeast Asia.

Coal-fired generation follows a different trajectory, peaking globally in the near term before entering a gradual decline. The outlook is shaped primarily by developments in China, which accounts for 55% of global coal-fired generation today and sees coal use in the power sector peak by 2030 before declining steadily. Coal-fired generation continues to grow to 2035 in India and to 2050 in Southeast Asia, reflecting strong electricity demand growth and the continued importance of domestic coal resources. By contrast, the European Union, Japan and Korea pursue a sustained reduction in coal use, driven by energy security objectives and emissions goals.

Oil use in the power sector is most concentrated in parts of the Middle East and North Africa, where oil has historically been used to meet peak electricity demand and support electricity supply. However, policies to diversify the generation mix and maximise the value of oil exports lead to sharp reductions in oil use for power generation in these regions, too. Saudi Arabia's increasing substitution of oil-fired generation with natural gas, renewables and nuclear power is emblematic of this trend (IEA, 2025).

Over the next decade, global power capacity nearly doubles, reshaping the mix of technologies (Figure 3.25). Renewables account for two-thirds of capacity additions to 2035 in the CPS, led by rapid growth in solar PV and wind. As a result, renewables constitute a clear majority of installed capacity by 2035, reflecting their cost competitiveness, short construction times and strong policy support. Conventional thermal technologies continue to play an important role, but their contribution to capacity growth is much smaller. These technologies increasingly focus on providing firm capacity, reliability and flexibility services in support of electricity security rather than bulk power (see Chapter 7). Battery storage capacity increases sixfold over the next decade, including behind-the-meter and utility-scale installations, a significant share of which are co-located with solar PV or wind projects (Box 3.7).

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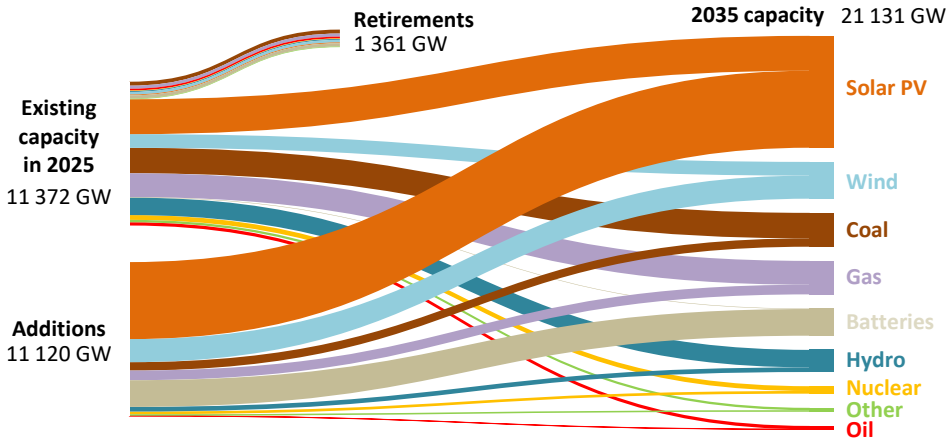
Figure 3.25 ▷ Global installed power capacity, additions and retirements in the CPS, 2025-2035



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The world keeps operating the vast majority of today's power fleet while adding enough capacity by 2035 to roughly double the size of the entire current system

Notes: GW = gigawatt. Other includes bioenergy, geothermal, concentrating solar, and marine power.

Box 3.7 ▷ Growing co-location of utility-scale battery storage and renewables

The co-location of utility-scale battery storage with solar PV and wind is expanding across many markets, and global additions continued to increase in 2025 despite a decline in China. Nearly 25 GW of utility-scale battery additions were paired with renewables in 2025, about 20% more than in 2024, as total utility-scale battery additions rose by over 55% to 93 GW. As a result, the share of co-located projects in total utility-scale battery additions declined to just over 25%. Behind-the-meter battery systems also continued to expand, though they are not included in these co-location figures.

Trends differ markedly across markets. In the United States, hybrid projects account for around half of solar PV and storage capacity in the interconnection queue, while in Europe, co-located battery storage capacity has risen almost 20-fold since 2020. Large renewable-plus-storage projects that aim to shift renewable output across the day and provide more consistent low-emissions supply are also emerging, including Masdar's 5.2 GW solar and 19 gigawatt-hour battery project in Abu Dhabi (United Arab Emirates). By contrast, co-located additions declined in China in 2025 due to market reforms.

Co-located projects can make better use of existing grid connections, reduce curtailment and improve renewable output value where capture prices are falling. However, they do not remove the need for wider network reinforcement. About two-thirds of co-located projects in operation today are paired with solar PV, 20% with wind and 10% with hybrid

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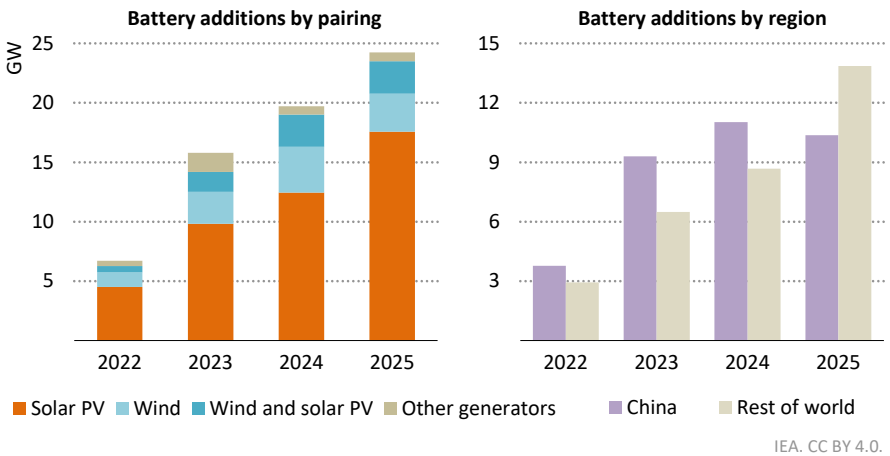
projects that have both solar PV and wind (Figure 3.26). For these projects, each megawatt (MW) of renewables is on average supplemented by 0.2 MW of battery capacity, with an average storage duration of 2.8 hours. For projects under construction, batteries are becoming larger per unit of paired renewables, with the ratio rising to 0.3 MW of batteries per MW of renewables, and average storage duration increasing to more than 3 hours.

Figure 3.26 ▷ Global battery storage capacity additions paired directly with solar PV and wind, 2022-2025



Thanks to falling battery costs and maturing supply chains, battery storage is being paired with solar PV and wind more often in many markets

Source: IEA analysis based on S&P Global Energy (2026).

Demand for battery storage is set to grow further as variable renewables expand, battery costs continue to fall, and market conditions incentivise deployment. In the CPS, global installed battery storage capacity reaches 1 000 GW by 2030 and 3 500 GW by 2050. Utility-scale batteries account for nearly 80% of global installed battery storage capacity in 2050, with behind-the-meter batteries making up the remainder.

3.4.3 Grids

Grids are the backbone of electricity systems, connecting power generation to end users while ensuring system flexibility, reliability and resilience. They are essential to deliver secure and affordable electricity, support economic development and enable the evolution of electricity systems. Globally, electricity networks deliver power with relatively high efficiency, with average losses of around 8% between generation and end use (IEA, 2023). As electricity demand grows and electricity supply evolves in the CPS, grids expand and

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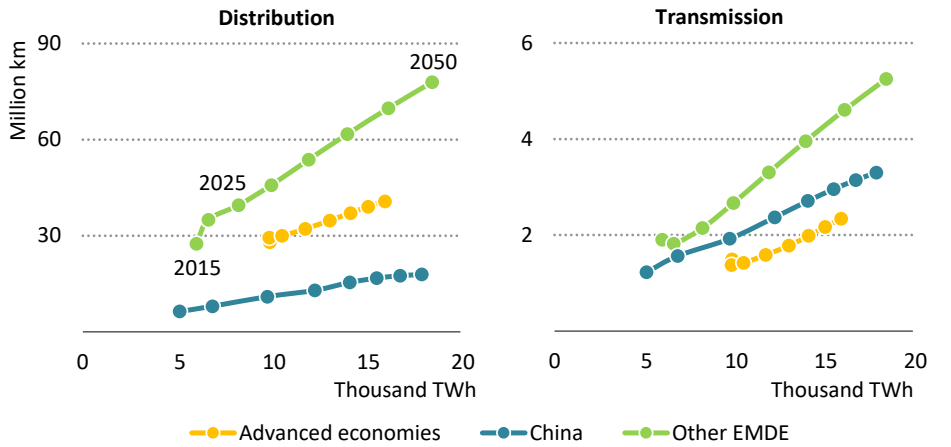
modernise to transmit higher volumes of electricity; integrate new installations of solar PV, wind and other sources; and extend electricity access.

Today's global electricity networks stretch more than 85 million kilometres (km) – nearly 55 million km in emerging market and developing economies, and around 32 million km in advanced economies. Over the past decade, global grids have expanded by 30%, or 20 million km. More than 90% of these new lines are in lower-voltage distribution networks, which transfer electricity from higher-voltage transmission lines to end users. In regions such as sub-Saharan Africa, much of this new distribution network in recent years has delivered electricity to communities for the first time. Transmission lines – which typically require longer project lead times due to their technical complexity and additional permitting – expanded by nearly 1 million km over the past decade. Although there are fewer of these lines, they play a key role in transmitting electricity over longer distances to reach all demand centres, in connecting regions and in enhancing grid resilience.

Figure 3.27 ▷ Electricity grid line length and electricity demand by type and region in the CPS, 2015-2050



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Electricity grid expansion continues in all regions, driven primarily by increasing electricity demand, with most growth in emerging market and developing economies

The principal driver of the recent grid expansion was increasing electricity demand, with new lines needed to connect new demand centres and provide additional electricity to existing ones. Over the past decade, the majority of grid growth was concentrated in emerging market and developing economies, where around 90% of electricity demand growth occurred. China alone accounted for more than 5 million new km, while other emerging market and developing economies added over 12 million km (Figure 3.27). Advanced economies added 2 million km of lines.

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Grid expansion needs depend not just on the extent to which electricity demand increases, but also on country-specific factors, including geography, population density and the balance of demand across sectoral end-uses. In China, for example, fewer additional kilometres of distribution grids are needed for each additional unit of electricity demand than in many other countries because of its relatively high population density – more than twice that of other emerging market and developing economies – and because buildings and transport account for a smaller share of total electricity demand than in most other countries. China's high-voltage transmission network has also grown rapidly over the past decade to deliver power from where it is produced – in the north and west of the country – to demand centres in the south and east. In many advanced economies, distribution network expansion needs are higher per unit of additional demand, in part due to relatively low population densities compared with China, as well as larger shares of buildings and transport in electricity demand.

In the CPS, grids expand as electricity demand increases, with 30% more new lines added by 2035 than in the previous decade. New lines continue to be concentrated in emerging market and developing economies, where the rate of electricity demand growth is more than double that of advanced economies. China adds more than 5 million km to distribution and transmission networks by 2035, and other emerging market and developing economies add around 15 million new km. In advanced economies, electricity demand growth by 2035 leads grids to increase in length by 5 million km, compared with 2 million km over the past decade. Globally, most of this grid expansion continues to be in distribution networks, including in China. In the CPS, the pace of grid expansion through to 2050 remains higher than in the past, with global grids approaching 150 million km, 70% higher than the total in 2025.

3.5 Fuels

The shocks to oil and gas supply brought about by the conflict in the Middle East bring few major changes to the long-term trajectory for these two fuels in the CPS. Most of the policy responses to date have focused on the near-term management of the 2026 energy crisis. New policies targeting a more enduring pivot away from imported fuels are not incorporated in the CPS, insofar as they are not yet fully embedded in legislation or regulation. Oil and gas demand continues to grow to 2050 (Figure 3.28), particularly in regions with abundant resources. Even though importers seek to develop new sources of domestic supply, supply growth remains concentrated in exporting countries, including those facing geopolitical or economic challenges today.

Oil remains the single largest energy source through to 2050, as structural declines in demand in China and advanced economies are more than offset by growth in India, Africa and Southeast Asia, and by rising demand for international aviation. The oil price surpasses USD 100/bbl in real terms by 2050.

Natural gas is the fastest-growing fossil fuel to 2050, with growth supported by rising demand in power generation and industry, mostly in emerging market and developing economies in Asia, as well as in resource-rich parts of the Middle East and North America.

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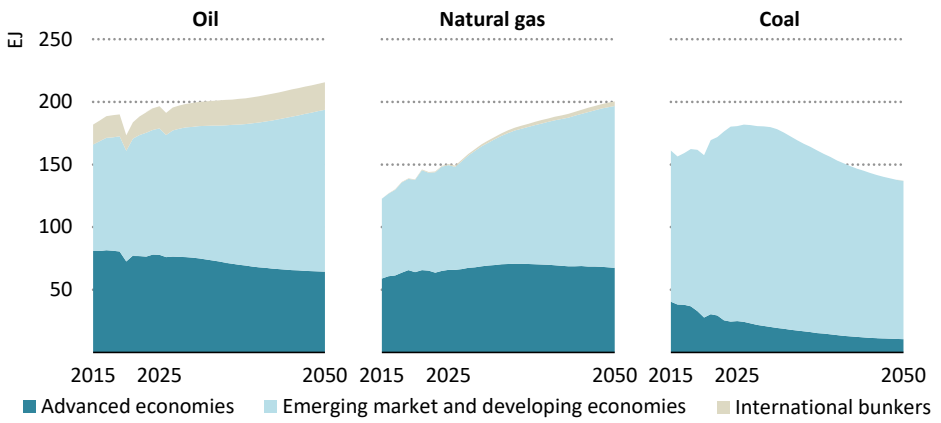
Figure 3.28 ▷ Fossil fuel demand by fuel in the CPS, 2015-2050



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Emerging market and developing economies continue to drive most change across fuels; natural gas overtakes coal before 2035, while oil remains the dominant fuel

Coal is the only modern energy source that declines in the CPS, and demand is nearly 10% lower in 2035 than today. All the decrease over this period occurs in the power sector, mostly in China, as coal is displaced by renewables and, to an extent, by natural gas. China's ample LNG infrastructure means it is well placed to benefit from a wave of new LNG supply.

Other fuels such as biofuels and biogases continue to grow, but from a low base; their combined share of total fuels demand rises from 8% in 2025 to 9% in 2035.

3.5.1 Oil

Demand

Global oil demand was 102 million barrels per day (mb/d) in 2025 and is expected to contract in 2026 due to the energy crisis caused by the conflict in the Middle East. In the CPS, it rises to 106 mb/d in 2035 and 114 mb/d in 2050 (Figure 3.29). The 0.4 mb/d average annual increase to 2035 is primarily driven by growth in petrochemical feedstocks (0.3 mb/d) and aviation (0.2 mb/d), while demand in most other sectors remains broadly flat or declines. Average annual oil demand growth then picks up slightly to 0.5 mb/d through to 2050, driven mainly by the expansion of the car fleet in emerging market and developing economies outside China, where stringent fuel economy policies are not yet in place and charging infrastructure for EVs remains limited.

Oil demand in advanced economies declines by an average of 0.7% per year to 2035. The European Union sees the steepest decline as EV adoption accelerates fuel substitution in road transport, although this decline is partly offset by growth in the United States, where rising petrochemical feedstock requirements and continued growth in mobility demand

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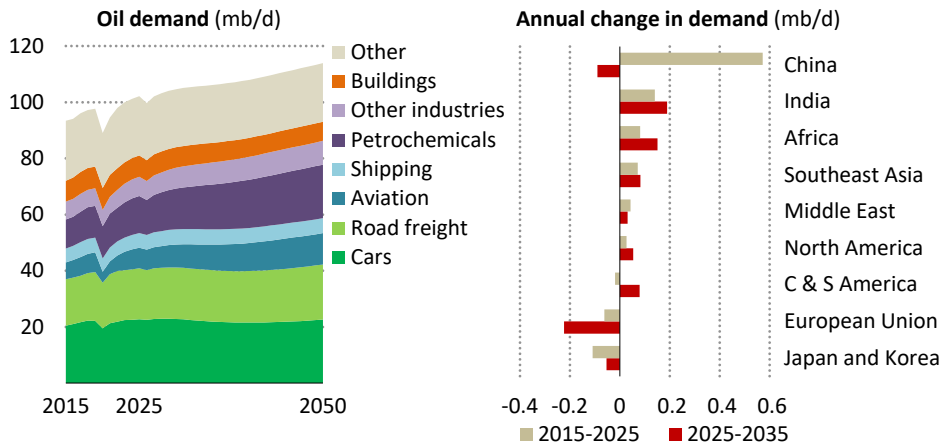
support higher oil consumption. Demand increases across nearly all sectors in emerging market and developing economies, with the strongest growth in India (3% per year on average to 2035), followed by Africa (2.8%) and Southeast Asia (1.4%). In the Middle East, demand growth driven by an expanding passenger car fleet and growing petrochemical activity supports higher oil use, although this is partly offset by a 1.1 mb/d decline in power sector demand. By contrast, oil demand in China – the source of more than 65% of global oil demand growth over the past decade – falls by 0.5% per year to 2035 as rapid transport electrification outweighs continued growth in petrochemical feedstock demand.

Figure 3.29 ▷ Global oil demand and average annual changes by region in the CPS, 2015-2050



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Global oil demand reaches 106 mb/d in 2035 and 114 mb/d in 2050, with growth in India, Africa and Southeast Asia offsetting declines in China and the European Union

Notes: mb/d = million barrels per day. Other industries = industry sector excluding petrochemicals. Other includes other non-energy use, other energy sectors, power, agriculture and other transport. Excludes biofuels.

Supply

The 4 mb/d increase in oil demand to 2035 in the CPS occurs alongside an almost 25 mb/d decline in production from existing conventional sources of supply, despite continued investment in recovery and extensions at these fields (Figure 3.30). Projects already approved, together with prospective production from existing unconventional basins, are insufficient to keep supply and demand in balance. Around 17 mb/d of additional supply therefore needs to be brought online by 2035, including from countries currently constrained by geopolitical conflict or international sanctions. Natural gas liquids (NGLs) are the fastest-growing segment of oil supply: they rise by 4 mb/d to 25 mb/d in 2035, while conventional crude oil output declines modestly.

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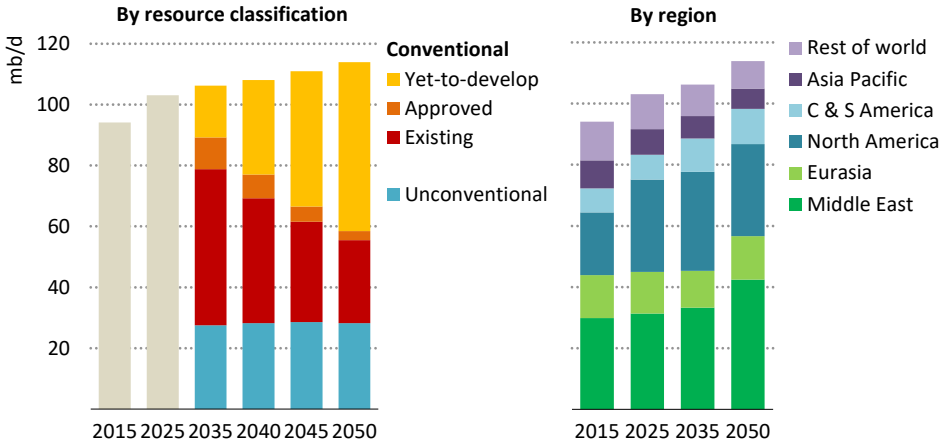
Figure 3.30 ▷ Oil supply by resource classification and region in the CPS, 2015-2050



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Existing and approved projects cannot meet the oil demand in 2035; around 17 mb/d of production is required from yet-to-develop projects

Notes: Existing supply includes production from resources already in development, including through primary, secondary and enhanced oil recovery, as well as extensions such as infrastructure-led expansions. Approved supply covers resources that have reached final investment decision as of 2026 and are scheduled to start production from 2026 onwards. Yet-to-develop supply covers discovered and undiscovered resources not yet approved for development. See Annex C for definitions of unconventional oil.

Middle East oil supply totalled 31 mb/d in 2025 but is set to fall significantly in 2026 following the disruption to flows through the Strait of Hormuz (see Chapter 2). In the CPS, production subsequently recovers, rising from its 2025 level by almost 2 mb/d to 2035 and reaching 42 mb/d in 2050. The increase is underpinned by expansions in production capacity and export flexibility across the Gulf, together with strong growth in NGL output, which rises by 45% and accounts for an increasing share of regional supply by 2035. Oil production in Saudi Arabia rises from 11.4 mb/d in 2025 to 12 mb/d in 2035; Qatar's output rises over the same period by 44% to 2.7 mb/d, including 1.7 mb/d of NGLs; output from the United Arab Emirates – no longer subject to Organization of the Petroleum Exporting Countries (OPEC) production quotas – reaches 5.8 mb/d in 2035, up from 4.4 mb/d in 2025 (Figure 3.31).

The United States accounted for 55% of global oil production growth between 2015 and 2025, driven by its tight oil revolution, and reached a new output record of 21 mb/d in 2025. Production increases in the CPS by a further 2 mb/d to 2035, supported by oil prices above USD 80/bbl and continued technological learning. This growth comes entirely from tight oil, led by the Permian Basin, and NGLs, which are primarily associated with shale gas production. Canada also reached a new output record in 2025, producing 6.4 mb/d including NGLs. It is expanding offshore development alongside export pipeline capacity for oil sands

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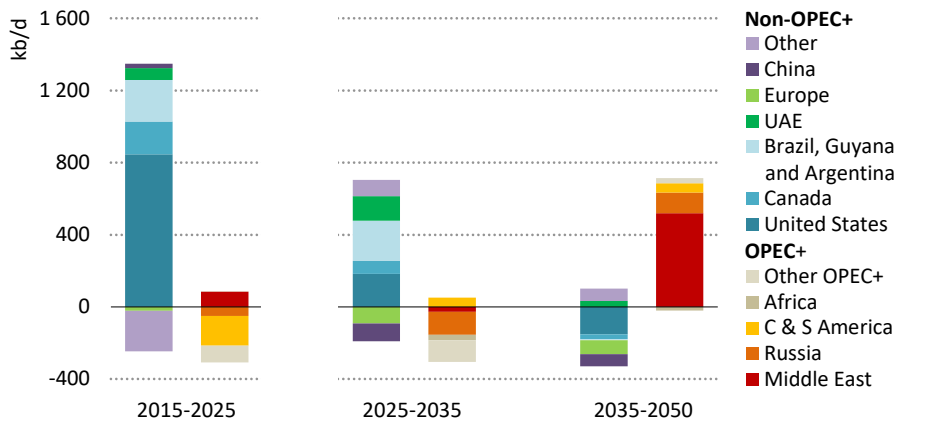
output, and its production rises by 0.7 mb/d to 2035. Mexico's Zama field is expected to be approved soon and come online in the early 2030s, but its output only partly offsets declines elsewhere, so production falls by 0.6 mb/d to 2035.

Figure 3.31 ▷ Average annual change in oil supply by producer in the CPS, 2015-2050



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Non-OPEC+ countries dominate production growth to 2035; high prices encourage most producers to exploit their resources fully, leaving OPEC+ to drive growth after 2035

Notes: kb/d = thousand barrels per day; OPEC = Organization of the Petroleum Exporting Countries; UAE = United Arab Emirates. Other includes rest of the world which is not part of OPEC+. See Annex C for further definitions.

Output in Central and South America grows in the CPS by almost 3 mb/d to reach 11 mb/d in 2035. Growth is led by Guyana (1 mb/d), where it is driven by the Stabroek Block; Brazil (0.8 mb/d), where it comes primarily through ultra-deepwater pre-salt expansions; and Argentina (0.6 mb/d), where it reflects Vaca Muerta shale development. As operators re-enter Venezuela's heavy oil sector, its production increases by 0.5 mb/d to 1.5 mb/d in 2035. Meanwhile, production of oil is set to begin in Suriname for the first time in 2028.

Africa is seeing renewed momentum in upstream investment, supported by policy reforms and new licensing rounds in Algeria, Angola, Cameroon and Libya. In Nigeria, the Bonga North project helps offset declines in mature fields, limiting the fall in oil production to 0.2 mb/d by 2035. Uganda and Namibia emerge as new producers, with first oil expected in 2026 and the early 2030s, respectively; output in each country reaches around 0.2 mb/d by 2035.

China produced 4.5 mb/d of oil in 2025, and new licensing rounds and brownfield campaigns have been launched to support domestic output. However, the country's mature resource base means production declines by 1 mb/d by 2035. Eurasian supply remains dominated by Russia, where production falls from 10.6 mb/d in 2025 to around 9 mb/d in 2035, reflecting

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rising costs and infrastructure constraints. New Arctic discoveries in Yamal, pending their appraisals, add to the Russian volumes. Additional pipeline connections serving Vostok Oil also support a modest recovery to 2050. Caspian output remains broadly stable at 3 mb/d to 2050.

Refining and trade

Refineries play a critical role in converting crude oil into the finished fuels and products required by end-users. There is currently around 106 mb/d of refining capacity globally, which processes around 84 mb/d of refinery feedstock[1] into approximately 86 mb/d of useful products, including LPG, naphtha, fuel oil, kerosene, diesel and gasoline. In recent years, there has been a significant increase in contributions to the liquids balance from sources that do not rely on refinery processing, notably NGLs excluding condensate (15 mb/d in 2025) and liquid biofuels (2.6 million barrels of oil equivalent per day [mboe/d] in 2025).

Traditionally, crude oil was transported, sometimes over long distances, to refineries located near consumption centres to be converted into fuels and other products. Since the early 2010s, however, new large-scale refinery hubs have been built in exporting regions such as the Middle East to make use of domestically produced oil, capture refining margins and expand refined products trade. Today, more than half of global oil production is traded internationally, with crude oil accounting for around two-thirds of oil trade volumes and products making up the remainder.

Figure 3.32 ▷ Net oil supply balance for selected regions, 2025



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Oil trade connects production centres in the Middle East, North America and Eurasia with major importers in Asia, Africa and Central and South America

Notes: Crude oil includes crude and condensate. Oil products include refined products, fractionated products and other fossil-derived liquid fuels.

[1] Refinery feedstocks include crude oil, condensate, bitumen and diluent.

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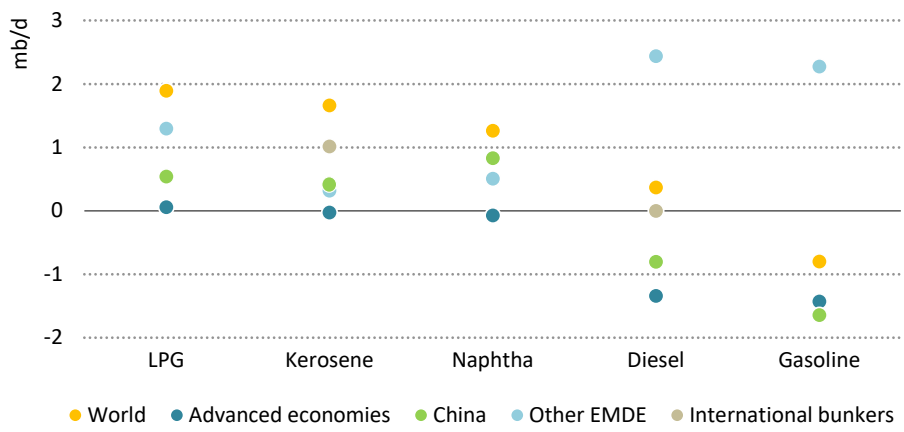
North America, the Middle East and Eurasia were the largest suppliers of refined and fractionated products to international markets in 2025, drawing on their significant domestic oil resources (Figure 3.32). Continued attacks on Russian refineries have cut Russia's product exports by around 0.4 mb/d since 2021, reducing them to 2.6 mb/d in 2025 and tightening global diesel balances. India exported more than 1 mb/d of refined products in 2025, including diesel, gasoline, naphtha and kerosene, supported by around 6 mb/d of refining capacity compared with 5.7 mb/d of product demand. At the same time, India is a major LPG importer (see Chapter 8). Asia and the European Union were the largest importers of refined and fractionated products in 2025. Limited domestic refining capacity means that Africa and Central and South America also imported refined products even while they exported crude oil.

Figure 3.33 ▷ Change in product demand in the CPS, 2025-2035



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Overall oil demand grows by 4 mb/d by 2035; demand falls for gasoline, stays broadly flat for diesel and rises for LPG, kerosene and naphtha

Notes: LPG = liquefied petroleum gas. No international bunkers for LPG, naphtha and gasoline.

In the CPS, demand for each of LPG, kerosene and naphtha increases by 1-2 mb/d to 2035, driven by growth in petrochemical feedstock demand and aviation activity (Figure 3.33). Diesel demand remains broadly flat to 2035, while gasoline demand declines by 0.8 mb/d, with growth in emerging market and developing economies outside China offset by declines elsewhere. Overall demand for refined products stays flat at 86 mb/d through to 2035. NGL production rises by 4 mb/d to 2035, with NGL-derived ethane, LPG and naphtha increasing in importance as low-cost alternatives to refined products for petrochemical feedstocks and cooking fuels. This growth is driven by increasing natural gas production, particularly in the United States and the Middle East. As petrochemical feedstocks are increasingly sourced from gas value chains (around 50% in 2035), refiners remain dependent on fuel products.

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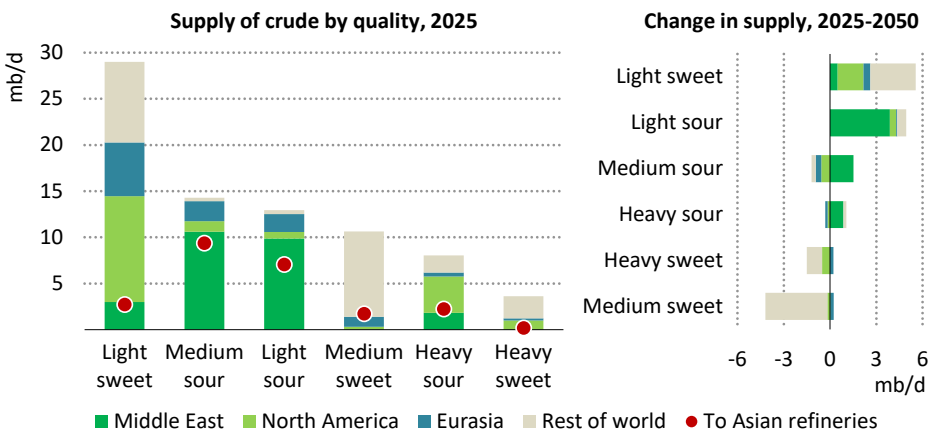
Although some newer refineries offer greater flexibility, the majority remain optimised to process a relatively narrow range of crude oils and cannot easily switch to alternative crude slates. Changes in crude density and sulphur content can alter product balances, strain refinery units and reduce the effectiveness of the overall refinery configuration. Higher sulphur content increases the need for hydrotreating and desulphurisation, while a greater share of heavy residual material often requires capacity to be upgraded, for example, by adding cokers and hydrocrackers. Conversely, a shift towards lighter, sweeter crude oils can constrain crude units, while reduced residual fuel output can limit feedstock availability for conversion units and potentially lead to lower utilisation rates and weaker refining margins. The challenge is therefore one of both technical compatibility and profitability.

Recent events have highlighted these constraints. Refineries across Asia are structurally optimised to process Middle Eastern sour crude grades. These supplies were severely disrupted as a result of the conflict in the Middle East (Figure 3.34). Much of the alternative crude available on the market was lighter and sweeter, requiring blending with heavier grades to meet refinery requirements. The shift in crude quality also reduced middle-distillate yields, compounding the loss of direct diesel and jet fuel exports from the Middle East and Russia.

Figure 3.34 ▷ Supply of crude by quality and change in the CPS, 2025-2050



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Asian refineries remain heavily reliant on Middle Eastern production of sour crude

Notes: Sweet crude contains less than 1% sulphur. Light crude has an API gravity above 32°. Heavy crude has an API gravity below 24°.

In the CPS, refinery configuration constraints continue to shape refining and trade patterns. Emerging market and developing economies in Asia, including China, account for around 60% of global crude imports by 2035, and this share increases to nearly 70% by 2050. The Middle East remains the dominant exporter, exporting roughly three times more crude oil than the next-largest exporting region. Without investment to enable them to process a wider range

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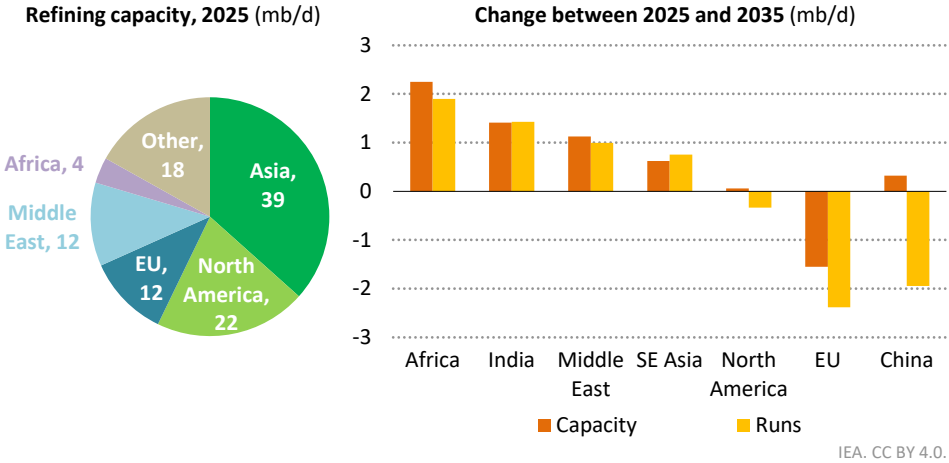
of crude slates, refineries in India, Southeast Asia and elsewhere in Asia will remain dependent on Middle Eastern sour crude supplies.

Around 7 mb/d of new refining capacity comes online in the CPS between 2025 and 2035, partly offset by 3 mb/d of closures. The largest share of new refining capacity is in Asia, led by India, where capacity expands from 6 mb/d in 2025 to 7.4 mb/d in 2035 (Figure 3.35). Southeast Asia adds 0.6 mb/d of refining capacity by 2035, slightly lagging demand growth of 0.8 mb/d. In China, however, falling oil demand and limited appetite to expand product exports lead to lower refinery runs, with utilisation rates falling by 11 percentage points to under 70% by 2035.

Figure 3.35 ▷ Change in refinery capacity and runs in the CPS, 2025-2035



Refinery capacity and runs increase in developing Asia and decrease in the European Union

Note: SE Asia = Southeast Asia; EU = European Union.

Africa's refining capacity increases by 2.2 mb/d to 2035. This includes the expansion of the Dangote refinery in Nigeria, with capacity rising from around 0.7 mb/d today to 1.4 mb/d by 2030. Meanwhile, Kenya's Lamu Island project adds around 0.7 mb/d of flexible refining capacity geared towards export markets. Middle East capacity rises by 1 mb/d to 2035, driven by incremental additions across the region, including in Saudi Arabia, Oman, Kuwait and Iraq. In Saudi Arabia, developments at one of the Yanbu refineries (currently in the pre-front-end engineering design phase) and the Jubail expansion add petrochemical integration to existing refining capacity. These plans are assumed to go ahead, despite attacks on Saudi Arabia's refining infrastructure in 2026. These projects continue the broader shift towards the integration of refining and higher-value chemicals production.

North America currently has around 22 mb/d of refining capacity. This capacity stays broadly flat to 2035 before increasing by 0.3 mb/d by 2050 to meet rising domestic and export

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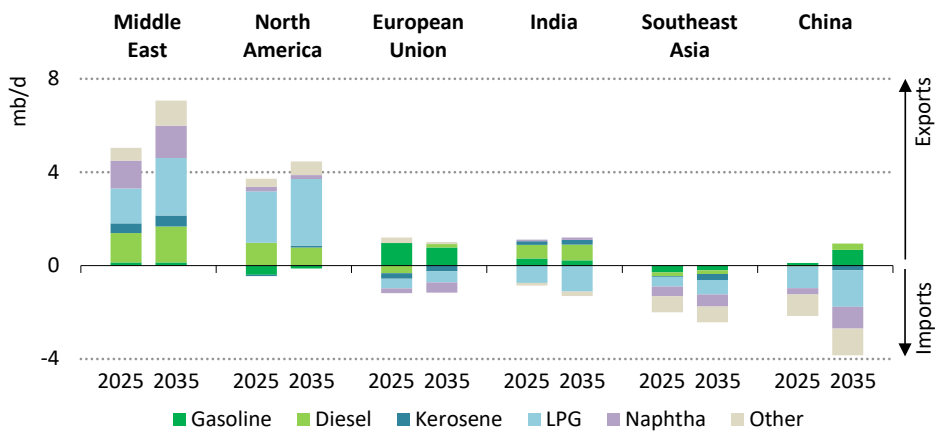
demand for petrochemical products, kerosene and diesel. Oil production in Central and South America rises by 3 mb/d by 2035, but limited refining growth means much of the additional crude must be processed elsewhere, leaving the region reliant on refined product imports. Refining capacity in the European Union falls from 12 mb/d in 2025 to 10 mb/d in 2035, reflecting weak international cost-competitiveness and declining demand for its main export product, gasoline.

The Middle East and North America remain the leading exporters of refined and fractionated products, despite refining capacity expanding in Asia. The evolving geography of the refining sector underlines the rising product import dependence in key consuming regions, particularly Asia.

Figure 3.36 ▷ Product trade balance for selected regions in the CPS, 2025-2035



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The Middle East and North America remain key product exporters with growing flows of LPG and naphtha to Asia

Note: Other includes ethane, fuel oil and other products.

Product trade volumes increase by 20% by 2035 in the CPS, driven primarily by growing trade in LPG, ethane and naphtha (Figure 3.36). In North America, rising NGL production boosts LPG and ethane exports, which increase by 25% by 2035. The Middle East records strong growth in LPG, naphtha and jet fuel exports, with net product exports rising from 5 mb/d today to almost 7 mb/d in 2035, supported by expanding natural gas production and higher refinery runs. Emerging market and developing economies in Asia, including China, account for around 45% of global oil product imports in 2035, up from 40% today. China remains the world's largest importer of LPG and naphtha, accounting for 40% of global imports in 2035. Demand for LPG also grows rapidly across developing Asia and Africa as access to clean cooking expands, with imports meeting more than 70% of the 1.5 mb/d increase.

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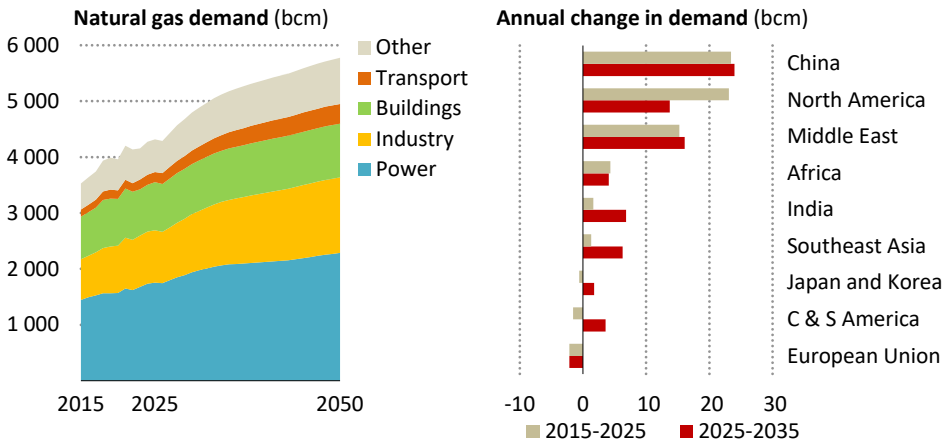
3.5.2 Natural gas

Demand

In the CPS, demand recovers rapidly from its contraction in 2026, supported by a wave of new gas and LNG supply due online over the next several years. Natural gas overtakes coal by 2035 to become the second-largest fuel in the global energy mix.

Almost all the increase in natural gas demand comes from emerging market and developing economies, where consumption rises by nearly 670 bcm to 2035. China is the single largest source of gas demand growth: its increase of 240 bcm between 2025 and 2035 is larger than the combined increase in all other countries in Asia. Gas demand doubles in India over the same period, and it rises by 35% in Southeast Asia. The Middle East, already a major gas consumer, sees a rise in demand of over 25%.

Figure 3.37 ▷ Global natural gas demand and average annual changes by region in the CPS, 2015-2050



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Gas demand increases by nearly 20% to 2035 and 30% to 2050, driven by its growing use in power and industry, particularly in Asia Pacific and the Middle East

Notes: bcm = billion cubic metres. Other includes energy sector own use and agriculture.

Demand in advanced economies rises by around 120 bcm between 2025 and 2035. In the United States, natural gas soon overtakes oil to become the largest energy source, and consumption increases by 13% to nearly 1 100 bcm in 2035. Japan and Korea see demand growth of over 10% over the same period. There is modest growth in Australia, Canada and Mexico. The European Union is alone among advanced economies in seeing natural gas demand in 2035 below its level in 2025 as the use of gas diminishes in power generation and across end-use sectors (Figure 3.37).

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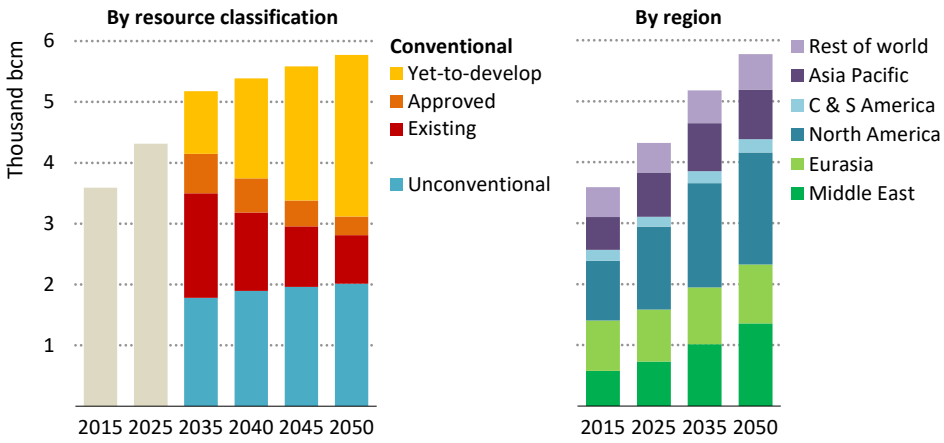
Supply

Natural gas supply increases in the CPS by around 85 bcm per year on average, reaching 5 200 bcm in 2035. Supply from unconventional projects rises by 30%, to 1 800 bcm in 2035, marginally increasing its share of overall supply. The contribution of existing conventional sources declines from 2 700 bcm in 2025 to 1 700 bcm in 2035 as mature resources are gradually depleted. A further 650 bcm of supply in 2035 comes from new conventional projects that had been approved as of 2026. Meeting projected natural gas demand growth in the CPS therefore requires substantial new investment in resource development and exploration: more than 1 000 bcm of additional conventional supply by 2035 comes from projects that have yet to be approved. This volume increases to around 2 600 bcm by 2050 (Figure 3.38).

Figure 3.38 ▷ Natural gas supply by resource classification and region in the CPS, 2015-2050



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Meeting rising natural gas demand requires around 1 000 bcm of additional supply by 2035 from projects yet to be approved and around 2 600 bcm by 2050

Notes: Existing supply includes production from resources already in development, including through primary, secondary and enhanced gas recovery, as well as extensions such as infrastructure-led expansions. Approved supply includes resources that have reached final investment decision as of 2026 and are scheduled to start production from 2026 onwards. Yet-to-develop supply includes discovered and undiscovered resources not yet approved for development. See Annex C for definitions of unconventional gas.

The United States is the world's largest producer of natural gas, and its output of around 1 100 bcm in 2025 accounted for more than one-quarter of global supply. The three most prolific basins – the Permian, Haynesville and Marcellus – have contributed more to global gas supply growth over the past decade than the whole of the Middle East. In recent years, activity has concentrated on the Permian Basin, which has accounted for 90% of incremental gas supply in the United States since 2023. In the CPS, production increases by a further

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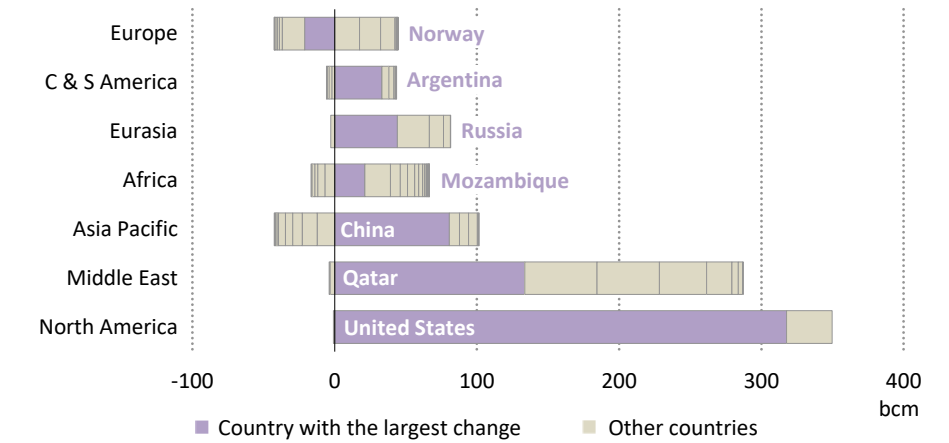
320 bcm by 2035. Growth remains underpinned by shale gas, even though annual growth in shale gas output to 2035 is around half the rate seen over the previous decade. Supporting both higher exports and growing domestic consumption requires additional upstream investment, and the Henry Hub price rises to around USD 4.7 per million British thermal units in 2035.

Figure 3.39 ▷ Change in natural gas production by country in the CPS, 2025-2035



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The Middle East and the United States deliver 70% of global gas production growth between 2025 and 2035

Note: Grey boxes denote other individual countries in the regional grouping.

In the CPS, the conflict in the Middle East puts only a temporary brake on the push to develop the region's gas resources, and the region sees the second-largest increase in production globally by 2035 (Figure 3.39), with output rising by 30% to 1 000 bcm. Qatar's natural gas production recovers rapidly, with damaged facilities fully restored by 2030, and it benefits from incremental growth from new offshore platforms that tap into the eastern and western parts of the supergiant North Field reservoir. Saudi Arabia is the second-largest source of supply growth in the region, with production led by the liquids-rich unconventional development in Jafurah. Meanwhile, growth in the United Arab Emirates is supported by the recovery and expansion of sour gas developments and by new upstream projects, notably the Bab gas cap development. Iran, the world's third-largest gas producer, quickly restores pre-conflict output and increases its gas production by 15% to 2035, despite economic sanctions, difficulties in attracting foreign investment and technological constraints, which limit further expansion.

In Russia, natural gas production in the CPS increases by 7% to 700 bcm by 2035, supported by a 25 bcm increase in exports. The Power of Siberia II pipeline to China is assumed to go

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ahead, and it gradually ramps up in the mid-2030s, creating a new export route for gas from the West Siberian and Yamal resource base that historically supplied Europe. This helps sustain production from mature supergiant fields such as Urengoy and Yamburg, while also encouraging continued development of newer fields. Turkmenistan sees modest supply growth as additional phases of the giant Galkynysh field are developed.

Gas production in Canada increases by around 30 bcm to 2035, driven by continued growth in shale and tight gas production, while rising LNG capacity supports the country's emergence as a major LNG exporter.

Natural gas production in Australia grows marginally to around 160 bcm by 2035. A domestic gas reservation scheme to be introduced from 2027 aims to improve domestic supply and strike a balance between future upstream export-driven projects and the needs of domestic gas consumers. Production growth comes from the Carnarvon and Browse basins, offsetting declines elsewhere.

Natural gas production in sub-Saharan Africa increases by around 60 bcm between 2025 and 2035. In Nigeria, efforts to revitalise upstream activity increase production by 20 bcm by 2035, while production in Mozambique triples, reaching 30 bcm in 2035. In North Africa, Algeria and Libya attract new investment by opening additional exploration acreage, and a string of new discoveries in Egypt strengthen upstream prospects there. However, declining production at mature basins causes overall production in North Africa to decline by 3% from its level in 2025 to 150 bcm in 2035.

Despite its resource maturity, European gas production grows marginally in the CPS to 2035, pushed up by some pockets of supply growth, notably in the East Mediterranean basins, such as offshore discoveries in Cyprus. First gas is expected in Romania's Neptun Deep project later this decade, while in Türkiye, output from the Sakarya field in the Black Sea continues to ramp up.

In Central and South America, production growth is concentrated in Argentina, where continued development of the Vaca Muerta formation and its substantial associated gas resources drives output up by nearly 70% from its 2025 level to reach about 80 bcm in 2035. Production also rises modestly in Brazil and Venezuela, although declines elsewhere in the region offset part of these gains. Overall, natural gas production in the region increases by nearly 40 bcm between 2025 and 2035.

Trade

Around 1 100 bcm of natural gas was traded over long distances in 2025, 48% by long-distance pipeline[2] and 52% as LNG. In the CPS, LNG trade quickly recovers ground lost from the disruption of flows via the Strait of Hormuz. Qatar's exports exceed pre-crisis levels by 2030 following the completion of repairs to its damaged trains and the commissioning of

[2] Long-distance pipeline trade refers to trade between 20 macro-regions in the Global Energy and Climate (GEC) Model (IEA, 2026b).

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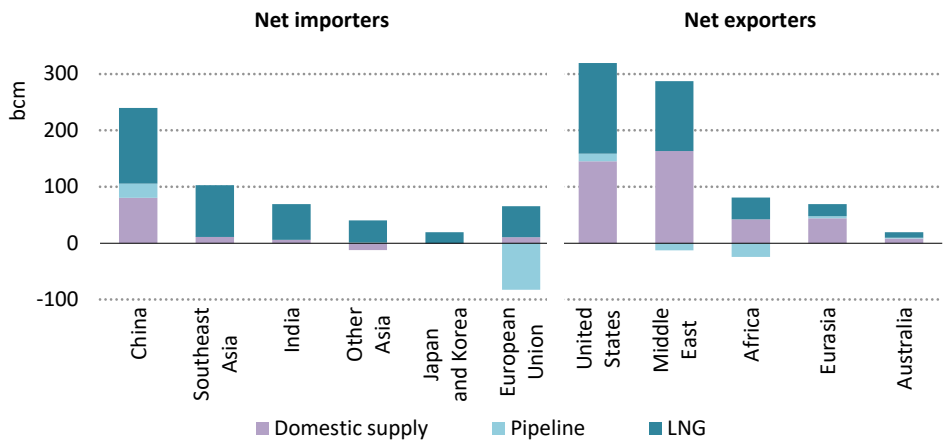
around 65 bcm of new export capacity at its North Field East and North Field South expansion projects. The United Arab Emirates' 13 bcm Ruwais LNG project is also commissioned by 2030. Overall Middle East LNG exports double in the CPS between 2025 and 2035, reaching 255 bcm. LNG exports through the Strait of Hormuz also double from their 2025 level to reach around 230 bcm in 2035, although the rapid rise in global LNG trade means that their share of total LNG supply rises only slightly compared to 2025 levels, to around 25% in 2035 (Figure 3.40).

Figure 3.40 ▷ Change in natural gas supply balance in selected regions in the CPS, 2025-2035



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The Middle East and the United States account for the majority of growth in global gas exports, with most of the additional supply making its way to Asia

Note: LNG = liquefied natural gas.

The United States is the world's largest LNG exporter, delivering around 150 bcm to more than 45 countries in 2025, largely under flexible, destination-free contracts allowing cargoes to be quickly redirected in response to market shifts. Export capacity more than doubles by 2035, by which time the United States delivers 35% of global LNG supply, solidifying its position as the world's dominant exporter.

Russia's annual LNG exports in 2035 increase by around 50% compared to 2025 levels. The European Union's decision to phase out imports of Russian LNG cuts off an important export outlet, but Russia redirects volumes to alternative markets, mainly in Asia. Shipping and sanctions-related constraints are assumed to continue in the CPS, keeping LNG exports well below their full potential. Net income from Russia's natural gas exports remains at least 40% below its 2021 level in 2035.

More than 70% of all LNG exports are shipped to Asia in 2035. China has emerged as a key balancing force in global gas markets in recent years, and this continues in the CPS. It

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imported around 90 bcm of LNG in 2025, making it the world's largest LNG importer, even though LNG meets only around 2% of its total energy demand. China has over 200 bcm of regasification capacity. It also has over 100 bcm of pipeline import capacity, through which it imported around 80 bcm of natural gas in 2025. With the growth of domestic liquefaction and storage capacity, alongside significant demand response capabilities, China can quickly adapt its gas supply balance to changing market conditions. In the CPS, it takes advantage of robust LNG supply growth, increasing imports by 130 bcm to 2035, while pipeline gas imports increase by 25 bcm, mostly from Russia.

Southeast Asia is currently a net LNG exporter; around 20% of its LNG production is traded within the region and the rest exported outside it. While new investments and recent discoveries in Indonesia and Malaysia help sustain LNG exports, the region as a whole becomes a net importer by 2030. A combination of rapidly rising demand and declining domestic production increases LNG imports to 100 bcm by 2035. An additional 50 bcm per year of regasification capacity is built to accommodate this growth.

In India, imports of LNG rise to nearly 100 bcm by 2035, up from 35 bcm today. Other emerging market and developing economies in Asia, particularly Bangladesh and Pakistan, see their collective imports rise by about 70% from today's level to around 80 bcm in 2035 in order to meet rising gas demand and compensate for declining output from mature domestic gas fields.

Japan and Korea – longtime leaders and first movers in the LNG industry – remain fully dependent on LNG to meet gas demand. Their combined imports rise in the CPS by about 15% from 2025 levels to reach around 170 bcm by 2035. EU LNG imports grow by 55 bcm between 2025 and 2035 to replace falls in pipeline imports from Africa, Norway and Russia.

Long-distance pipeline trade declines globally, with modest growth concentrated in Eurasia. In the CPS, China increases gas imports from Russia from 38 bcm in 2025 to 56 bcm in 2035. The Power of Siberia I pipeline is currently operating at its full capacity of 38 bcm per year, and the Far East pipeline is expected to come online in 2028, increasing exports by 12 bcm. In addition, the Power of Siberia II pipeline, with a planned capacity of 50 bcm, is assumed to ramp up from the mid-2030s. Russia also marginally increases exports to the Caspian region, making use of existing regional infrastructure. A significant portion of these exports goes to Kazakhstan and Uzbekistan, both of which face rising domestic demand and declining output from mature fields. Other pipeline interconnections are built in the East Mediterranean, notably between Cyprus and Egypt.

3.5.3 Coal

Demand

Coal demand has risen by nearly 90% since 2000, driven primarily by growth in emerging market and developing economies in Asia, and it reached a record high of 6 165 million tonnes of coal equivalent (Mtce) in 2025. The power sector remains the largest source of coal demand, accounting for around two-thirds of consumption today, and around 25% is

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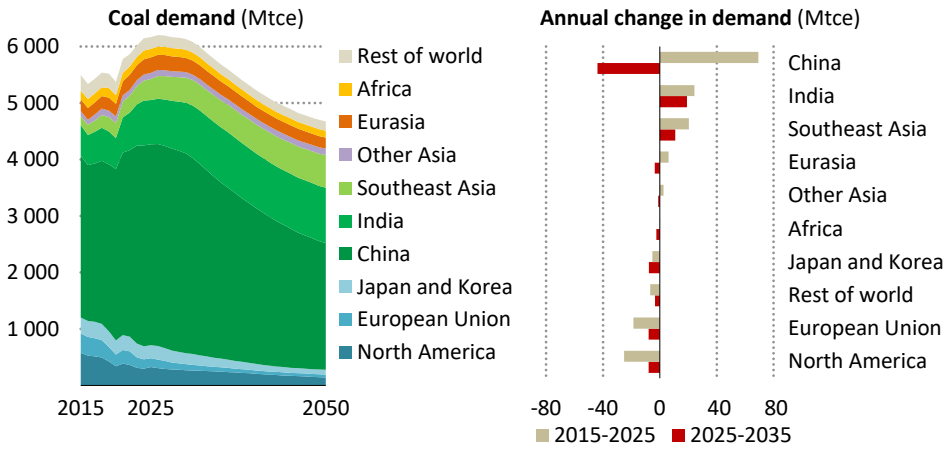
used in industry, mainly for steel and cement production. In the CPS, global coal demand peaks before 2030 and then declines gradually (Figure 3.41). By 2035, demand is nearly 10% lower than today, with reduced use of coal in the power sector heavily outweighing a slight rise in coal use in industry.

Figure 3.41 ▷ Global coal demand and average annual changes by region in the CPS, 2015-2050



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Global coal demand peaks before 2030 as declining consumption in China and advanced economies outweighs growth in India and Southeast Asia

China remains by far the largest coal consumer, accounting for 55% of global demand in 2035. It increases coal-fired power capacity by 35% to 2035, but coal use in the power sector drops by nearly 15% over the same period because of a shift from using coal for baseload power towards drawing on it to support the power system when needed. China's coal-to-gas and coal-to-liquids sector consumed around 50 Mtce in 2025 to produce around 0.4 mboe/d, and the output more than doubles by 2035. The largest regional increases in coal demand to 2035 come from India and Southeast Asia. In advanced economies, coal demand continues its structural decline, with consumption falling by over 30% to 2035.

Supply

In 2025, global coal production stood at an all-time high of 6 375 Mtce,[3] dominated by steam coal (80%) and coking coal (15%), with lignite and peat accounting for the remainder. In the CPS, global production declines by around 10% to 2035 (Figure 3.42). By 2050, production is nearly 30% lower than today, with steam coal down 30% and coking coal down 20%.

[3] Coal supply in 2025 was around 205 Mtce higher than demand, reflecting oversupply in Eurasia and Southeast Asia and stock building in China.

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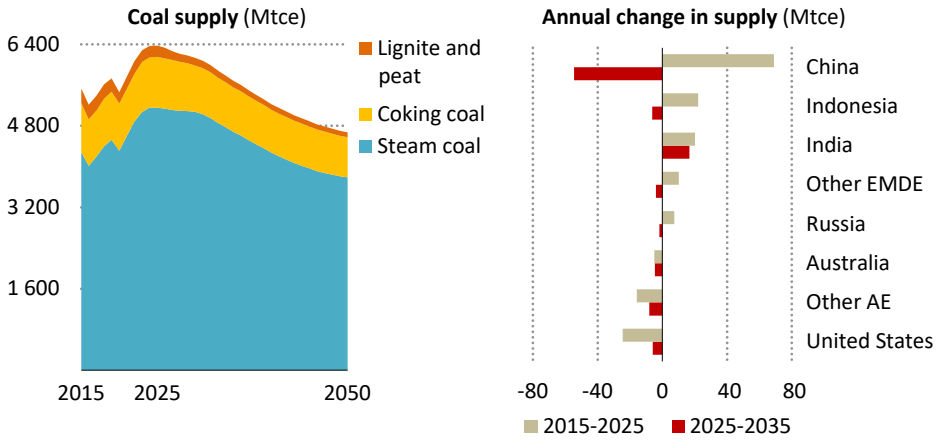
Figure 3.42 ▷ Coal supply and average annual change in supply by region in the CPS, 2015-2050



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The geography of production is shifting: output declines in China and Indonesia and increases in India and a handful of emerging producers

Note: Other EMDE = emerging market and developing economies excluding China, India, Indonesia and Russia; Other AE = advanced economies excluding Australia and the United States.

The outlook for coal supply is strongly influenced by China, the world's largest producer, which accounts for more than half of global output today. In May 2026, a mine explosion in Shanxi killed over 80 people and injured more than 100 others. The subsequent programme of safety checks is set to impact near-term production. However, what drives China's fall in production of over 15%, or 545 Mtce, by 2035 is its declining domestic need for coal. Although this reduction in production is equivalent to losing 95% of the output of India today, China remains by far the world's largest coal producer to 2050, reflecting the scale of its resource base and coal mining sector.

In India, coal production grows by more than anywhere else, strengthening its position as the world's second-largest producer. Total coal output rises by almost 30% to 2035, driven by an acceleration in the production of steam coal. Expanding output draws on large proven reserves concentrated in eastern and central states, while the high share of surface mining keeps production costs relatively low. This growth in production meets nearly 90% of incremental domestic coal demand to 2035, limiting the need for additional coal imports.

Production in Indonesia declines from a peak of nearly 610 Mtce in 2024 to around 510 Mtce in 2035 in response to low prices in international markets and lower demand from China, which continues to absorb a large share of Indonesian coal exports. Other countries in Southeast Asia see production either plateauing or increasing to 2050. In northern Asia, export-driven production in Mongolia rises in the near term before hovering around 100 Mtce through the 2030s. In Africa, some small and emerging producers see rising

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production to 2050: these include Mozambique, which has significant resources, including export-grade coking coal. By contrast, Colombia's production continues to decline from its peak in 2017 as coal demand contracts in its main export markets in Europe and Colombia struggles to compete in the Asian market.

The outlook varies by coal type in most countries. In the United States, the production of steam coal continues its long-term decline, while coking coal output increases slightly through to 2050, boosting exports. Steam coal production in Australia also falls as the use of coal for power generation declines in Chinese Taipei, Japan and Korea, while Australia's coking coal output grows to meet industrial demand in India and Southeast Asia. In Russia, steam coal production declines as global demand weakens, while coking coal production plateaus over the outlook period, supported in part by the expansion of the Elga mine.

Trade

Global coal trade shrinks over the outlook period from around 1 160 Mtce in 2025 to 1 060 Mtce in 2035 and 915 Mtce in 2050 (Figure 3.43). Continued coal demand growth in developing Asia and gradual declines in coal use in China and advanced economies help sustain trade volumes into the 2030s, but a drop of just under 10% in global coal demand by 2035 leads to a contraction in trade. Rising output in India limits growth in its import requirements, meaning traded steam coal volumes fall more quickly than overall steam coal demand. Seaborne steam coal trade also comes under pressure from the increasing use of low-emissions sources in the power sector. By contrast, coking coal trade remains comparatively robust, underpinned by expanding steel production in India and other emerging market and developing economies, and by the limited availability of high-quality domestic coking coal resources.

China is the single most important driver of changes in global coal trade. Following a peak in demand, Chinese coal imports fall by 20% to 2035, reducing global import requirements by around 75 Mtce, equivalent to 85% of industrial coal demand in Southeast Asia today. China's imports of both coking coal and steam coal decline significantly, with total imports falling by half by 2050. China's lower import needs have an impact on all major exporters, but they particularly affect Indonesia. Total Indonesian exports fall from 385 Mtce in 2025 to 265 Mtce in 2035, with 70% of the decline explained by reduced exports to China. Exports from Australia and Mongolia to China also decline over time, although the impact is more muted for suppliers with greater exposure to coking coal markets.

India becomes the largest importer in the 2040s, as total coal imports hover around 230 Mtce, similar to today's levels, before declining slightly to 2050. Australia is the principal beneficiary of growing seaborne coking coal demand, with coking coal exports increasing by around 10% by 2035 and 25% by 2050. Growing shipments to India and Southeast Asia partially offset declining exports to China, Japan and Korea, meaning that the Asia Pacific region continues to account for around 80% of global imports. Exports from Australia to India alone rise from close to 65 Mtce in 2025 to around 90 Mtce in 2035.

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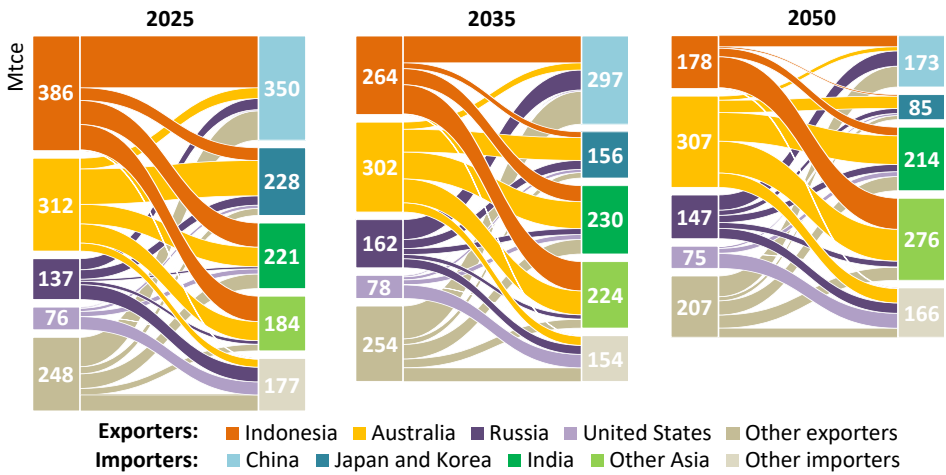
Southeast Asia, excluding Indonesia, increasingly becomes a key destination for coal exports: imports increase by around 20% by 2035 and 50% by 2050, sourced mainly from suppliers in Australia and Indonesia. The region becomes one of the few large coal-importing markets still expanding to 2050. In northern Asia, Mongolia continues to export the majority of its production to China's steel sector. In Africa, Mozambique emerges as an additional supplier of coking coal to Asia, seeing sustained growth in exports to 2050.

Figure 3.43 ▷ Net coal trade in the CPS, 2025-2050



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Contracting steam coal imports in advanced Asia and China and robust coking coal demand in developing Asia see Australia overtake Indonesia as the largest coal exporter

Note: The largest coal exporters and importers are ordered by net coal trade in energy-equivalent terms in 2025. 'Other exporters' include South Africa, Mongolia, Colombia, Canada, Caspian, Mozambique, New Zealand and Venezuela; 'Other importers' include Europe, the Middle East, North Africa, and the rest of Latin America and sub-Saharan Africa.

3.6 Investment

Energy investment in the CPS rises from USD 3.3 trillion today to an annual average of USD 3.6 trillion over the next ten years. Two-thirds of energy investment in 2035 is spent on renewables, nuclear, grids, storage, low-emissions fuels, efficiency and electrification, and one-third on fossil fuel supply and power generation. Advanced economies account for nearly 45% of global energy investment to 2035, China accounts for around 25%, and other emerging market and developing economies account for around 30%, despite being home to around two-thirds of the world's population. India is the region that sees energy investment grow the fastest in the next decade, by 85% to an average of USD 200 billion per year. Other emerging market and developing economies also increase their spending

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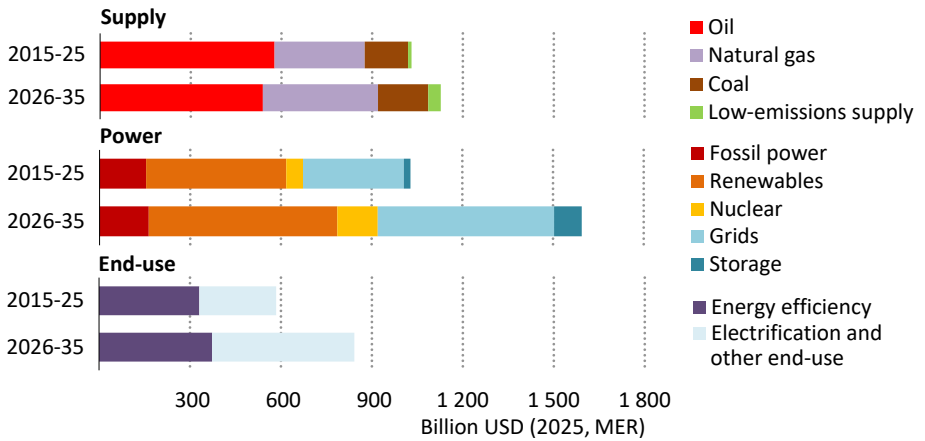
considerably – Africa increases annual average spending by 45% while it grows 60% in Southeast Asia.

In the CPS, fuel supply investments average USD 1.1 trillion annually to 2035 and are almost 10% higher over the next ten years than in the last decade (Figure 3.44). Oil supply investment averages almost USD 540 billion per year to 2035, which is 7% lower than over the previous ten years. Natural gas supply investment averages USD 380 billion per year over the same period, which is 30% higher than over the last decade, with most of the growth in spending taking place in emerging market and developing economies. Coal supply investment averages USD 165 billion per year over the next decade. Meanwhile, investment in low-emissions fuels more than triples to an average of over USD 40 billion per year, with growth coming primarily from biofuels.

Figure 3.44 ▷ Average annual energy investment in the CPS, 2015-2035



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Energy investment rises by 35% to 2035, driven by the power sector, which sees spending increase by 45% on low-emissions power and 90% on grids and storage

Note: MER = market exchange rate.

Power sector investment in the CPS averages USD 1.6 trillion per year over the next decade, which is 55% higher than in the past ten years. Average annual fossil generation investment increases by 5%, driven by higher gas generation investment worldwide. In the United States, gas generation spending averages USD 36 billion per year from now to 2035, compared to less than USD 15 billion in the last decade, driven by the increasing power needs of data centres and AI. Low-emissions generation investment continues to grow around the world, with investments in solar and wind power increasing by 15% and 50%, respectively, in the next decade, compared with the last. Average annual investment in solar and wind more than doubles in India and the Middle East, and it almost triples in Africa and Southeast Asia.

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Nuclear's share of total generation investment rises from 9% today to 20% in 2035: nuclear investment grows from USD 55 billion per year in the last decade to around USD 135 billion on average to 2035, supporting new construction, lifetime extensions and reactor restarts.

Battery storage investments more than quadruple to an average of USD 90 billion per year through to 2035, compared to the previous decade, while transmission and distribution investments increase by 75% to an annual average of USD 585 billion. China remains the biggest spender on grids, with investment rising to support the continued expansion of west-to-east transmission corridors. Advanced economies invest heavily as well, with average spending to 2035 growing by 75% to modernise ageing infrastructure, integrate greater shares of renewables and enhance regional interconnection. The rest of the world boosts investment in grids by 60% to support growing electricity demand. Average annual investment doubles in India and grows by 75% in Central and South America.

Investments in energy efficiency, electrification and other end-uses increase by 45% to an annual average of USD 840 billion over the next decade, with spending on the electrification of end-uses almost doubling relative to its 2015-2025 average. Average annual energy efficiency investments increase by almost 15% to 2035, with most capital directed at improvements in buildings.

Investment in EVs and EV charging facilities grows to an average of USD 300 billion per year over the period to 2035. China maintains its position as the largest investor, spending an average of over USD 105 billion per year in the next decade on vehicles and charging facilities, while the European Union spends USD 85 billion and North America nearly USD 30 billion. Investment in EVs in EMDE outside of China grows almost eightfold to an average of nearly USD 30 billion per year.

North America, the largest spender on oil supply, sees a nearly 20% decline due to improved efficiency, despite sustained production levels (Figure 3.45). Over the next decade, structural declines in oil investment in China and advanced economies are partially offset by a rise in annual average spending in emerging market and developing economies, including Africa, Central and South America, Eurasia and India, as export prospects are lifted by new discoveries, growing upstream activity and project expansions. The Middle East also sees increased spending on oil production and infrastructure In the short term as damaged assets and facilities are repaired and brought back online, then spending moderates to 2035.

Growth in natural gas supply investment mostly comes from Africa, Eurasia, the Middle East and North America. Spending in the Middle East grows by 80% to an average of USD 50 billion per year over the next decade. This reflects the need to recover Qatari gas production as well as increases in natural gas production in Saudi Arabia and the United Arab Emirates. Annual investment in natural gas liquefaction capacity more than triples in Africa to average USD 4.5 billion per year and rises by 15% in North America to USD 13 billion per year over the period to 2035. India, Japan and Korea, and Southeast Asia see increased investment in regasification infrastructure, while other importing regions such as China and the European Union invest less over the next decade.

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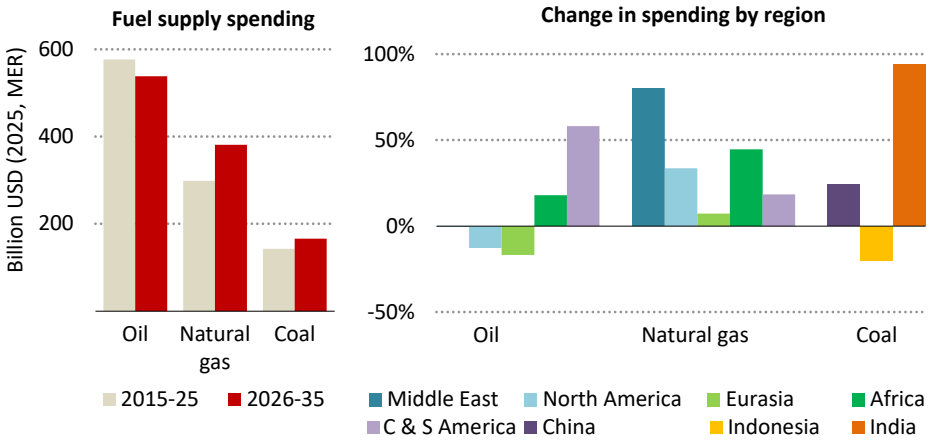
Figure 3.45 ▷ Average annual investment in fossil fuel supply and change in spending in selected regions in the CPS, 2015-2035



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EMDE account for 65% of fossil fuel supply spending in the next decade; natural gas supply spending grows by nearly 30%, led by Africa and the Middle East

Coal supply investment varies widely between major producers. In China, the world's biggest spender on coal supply, investment remains elevated through 2030 before declining as domestic coal demand and production fall. Despite the later downturn, average annual spending remains 25% higher than over the last ten years. India's investment in coal supply almost doubles to average USD 23 billion annually as it seeks to exploit abundant coal reserves in central and eastern states to support the country's growing power generation needs and expanding iron and steel production. By contrast, Indonesia, which accounts for 90% of Southeast Asia's coal output, decreases its spending by 20% over the next decade as weaker international prices and declining demand weigh on production.

3.7 Employment

In the CPS, energy employment plateaus at around today's historically high levels after strong growth in recent years, with total energy employment rising 1.8% to 79.6 million workers by 2035. While the workforce expands in the power and supply sectors, energy efficiency jobs decline, and vehicle manufacturing employment grows only marginally (Figure 3.46).

Jobs in the power sector continue to grow, but at a slower pace than electricity demand. Operational jobs continue to grow at rates similar to the previous decade, but these gains are partially offset by a decline in development-stage jobs, as investment in new generation capacity falls from its current peak. The biggest reductions in development-stage jobs are in solar PV and unabated fossil-based generation. The share of low-emissions jobs in power generation employment grows from 73% in 2025 to 78% by 2035.

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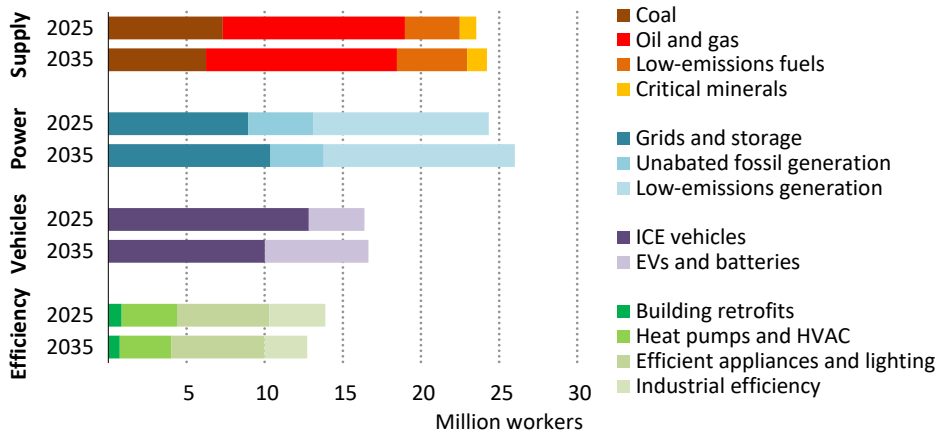
Figure 3.46 ▷ Global energy employment by sector in the CPS, 2025 and 2035



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Energy sector employment rises by 1.4 million by 2035, driven by growth in the power and supply sectors

Note: EVs = electric vehicles; HVAC = heating, ventilation and air conditioning.

Total employment in fuel and critical minerals supply grows by 0.3% per year to 2035, although trends differ between sub-sectors. Oil and gas supply adds 570 000 jobs by 2035, as demand for these fuels recovers from a contraction in 2026. Coal jobs continue their structural decline, falling by 1.1 million, or 15%, by 2035. This contraction is driven by dwindling global coal demand, in contrast to the past decade, when reductions in job numbers arose primarily from automation and from labour productivity improvements in China. Low-emissions energy and critical minerals supply see continued strong growth, with the number of jobs rising by 1.2 million, or 26%, by 2035.

As the sales share of EVs continues to rise, EVs and their batteries account for 40% of overall vehicle manufacturing employment by 2035, up from 22% today. In contrast, energy efficiency jobs fall by 8%, as energy efficiency improvements in buildings and industry remain modest.

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The Stated Policies Scenario

Rebalancing the system?

SUMMARY

- The Stated Policies Scenario (STEPS) considers the implications of a broader range of policies than the Current Policies Scenario and offers a more dynamic perspective on energy technology and market trends, allowing for a slightly more rapid introduction of new energy technologies. As such, it provides more scope to incorporate responses to the 2026 energy crisis from governments, markets and investors.
- The scenario assumes that the effects of the conflict in the Middle East on fuel supply fade in 2027. This shifts oil and gas markets from tight to relatively well-supplied conditions, supported by higher output from the Middle East, the United States, and other producers in the Americas.
- In the STEPS, structural shifts, including rising transport electrification, are sufficient for oil demand to level off at around 103 million barrels per day around 2030 before entering a slow decline. Natural gas demand grows until the mid-2030s, albeit not quickly enough to absorb the wave of new liquefied natural gas supply. In aggregate, renewables see the largest demand increase of all fuels. China accounted for over half of global energy demand growth over the past decade, but most of the growth to 2035 in the STEPS comes from other emerging market and developing economies.
- The Age of Electricity, powered increasingly by renewables, represents a big efficiency gain for the energy system, slowing energy demand growth from 1.6% over the past decade to 0.8% per year to 2035. Electricity's share in total final energy consumption rises from 23% today to nearly 30% by 2035 in the STEPS, with electricity demand growing over four times faster than total energy demand. Cooling demand increases by 1 700 terawatt-hours by 2035, but more frequent heatwaves could add to this. Grids expand by 26 million kilometres (km) of new lines; around 16 million km of existing lines will also need to be replaced or refurbished by 2035.
- In the power sector, renewables provide half of global generation by 2035 in the STEPS, up from 33% today, and solar photovoltaics becomes the largest source of electricity. Nuclear makes a comeback, its share of generation edging up from 9% to 10% by 2035, while gas-fired generation grows but loses market share. By 2035, coal-fired power generation falls from 34% today to just above 20% in 2035, though the long-term decline is less steep than in the 2025 edition of the STEPS.
- Energy-related carbon dioxide emissions peak before 2030 in the STEPS and start a gradual decline, mainly because of lower coal-fired power generation in advanced economies and China. Energy investment grows by 40% up to 2035 compared to the previous decade, with two-thirds of the increase going to low-emissions power, grids and storage. Energy employment continues to grow, especially in the power sector, electric vehicle manufacturing and efficiency.

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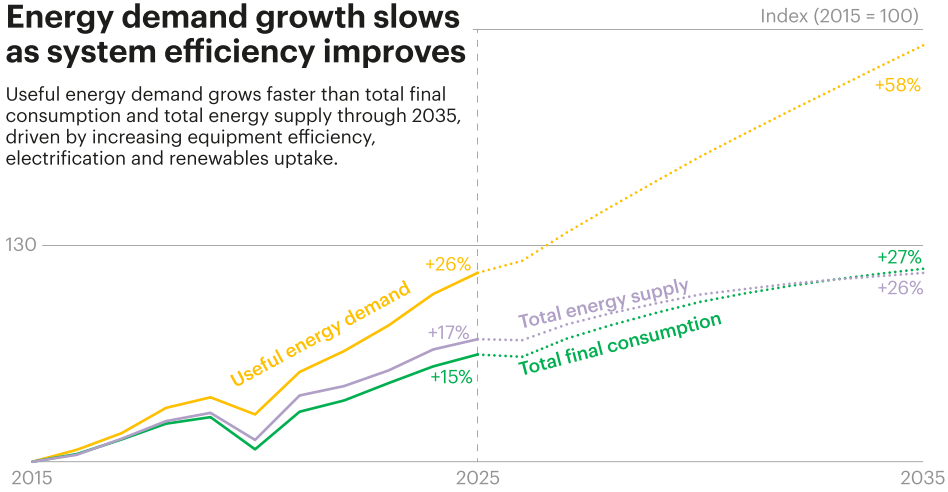
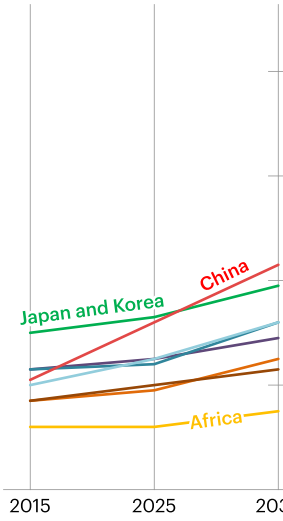
Energy demand growth slows as system efficiency improves

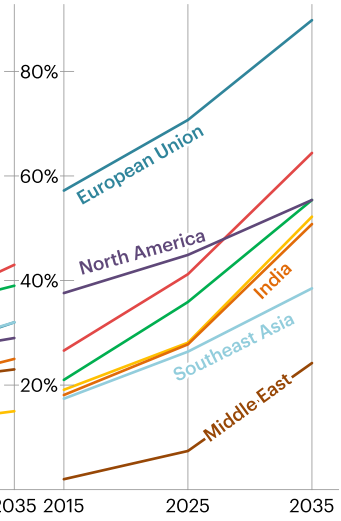
Useful energy demand grows faster than total final consumption and total energy supply through 2035, driven by increasing equipment efficiency, electrification and renewables uptake.



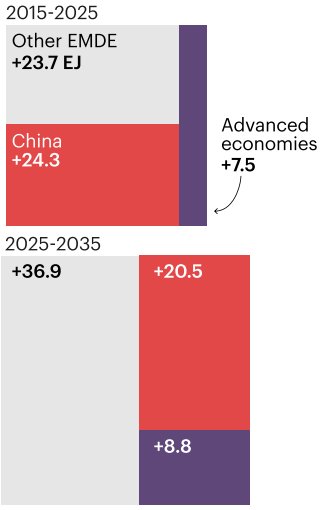
Share of electricity in total final energy consumption



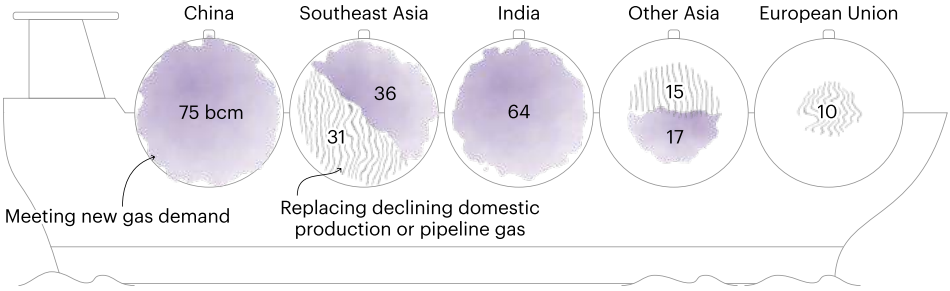
Share of renewables and nuclear in electricity generation



Growth of useful energy demand



Drivers of growth in LNG demand in the STEPS, 2025-2035



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4.1 Introduction

The Stated Policies Scenario (STEPS) gives a more dynamic reading of prevailing policy settings than the Current Policies Scenario (CPS) described in the previous chapter. Although it builds on the same foundations – energy and energy-related policies that are in place – it also considers policies that have been put forward but have not yet been adopted across different sectors of the energy economy. However, it does not assume that aspirational goals, such as those included in some Nationally Determined Contributions, are achieved. It also differs from the CPS in allowing for a continuation of current processes of technological change and greater deployment of new energy technologies following recent market trends. Like the CPS, the STEPS is an exploratory scenario and does not target a predetermined outcome. Instead, it sets the starting conditions and sees where they lead.

Assumptions on the conflict in the Middle East are likewise shared with the CPS. In both scenarios, constraints on exports from the Gulf arising from the conflict ease into 2027, and conditions are assumed to be sufficiently stable to allow for unimpeded transit through the Strait of Hormuz by the end of 2027. The conflict is causing many energy market participants to consider what lessons should be drawn from the energy crisis it precipitated. The design of the STEPS allows it to reflect more policy and market responses to the energy crisis than the CPS. Most of these responses focus on energy security and resilience and seek to build on structural changes that were already underway prior to the crisis – by placing greater emphasis on renewables and electrification, for example.

This chapter presents new projections for the STEPS, starting with an overview of the outlook for energy demand and emissions. It then goes into more detail on end-use sectors, where it looks at the development of the global vehicle fleet and examines how heat waves affect cooling demand. The electricity section looks in detail at the rapid growth in electricity demand as well as continued structural changes in the generation mix in many countries. The chapter then turns to the outlook for oil, natural gas, coal and low-emissions fuels, including an extended analysis of how liquefied natural gas (LNG) balances play out in a world of ample supply but some concerns among consumers, particularly in Asia, about the risks of future supply disruption and price volatility. The chapter concludes with sections on the investments required under the STEPS and the implications for energy-related employment.

4.2 Overview

4.2.1 Total energy demand

Total energy demand increases in the STEPS from 667 exajoules (EJ) in 2025 to around 720 EJ in 2035, with average annual growth of 0.8%. This is half the annual growth rate seen over the previous decade. The slower rise in energy demand reflects continued improvements in the energy intensity of the global economy, supported by higher electrification in end-use sectors and the growing role of renewables in the power sector. Global gross domestic product (GDP) is assumed to grow by 3% per year to 2035, broadly in line with the past

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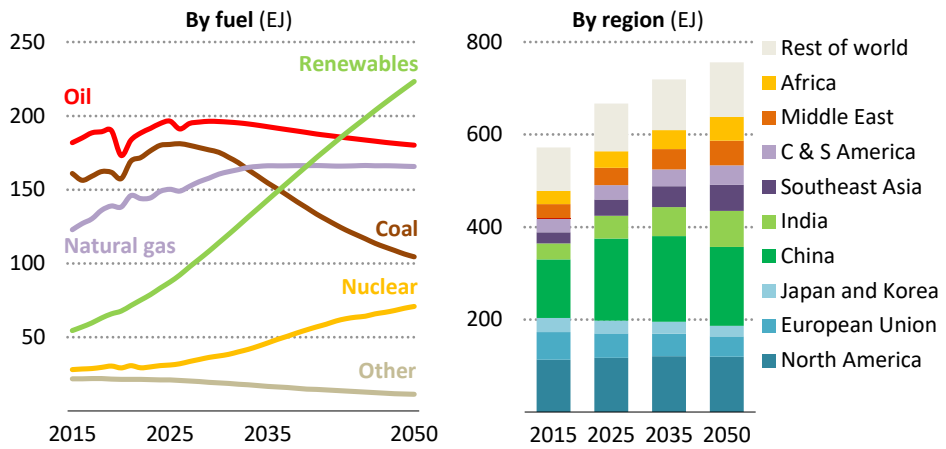
decade, while useful energy demand grows by 2% per year, supported by the continued growth of the global car fleet and the stock of air conditioners (ACs).

Fossil fuels accounted for 79% of total energy demand in 2025, down three percentage points from their 82% share in 2015. Their share of the total declines by a further eight percentage points to 71% over the next decade in the STEPS as renewables and nuclear expand by 65% and 50%, respectively. Coal demand peaks before 2030 at around its current level of 6 165 million tonnes of coal equivalent (Mtce) and then declines steadily to 2035 as its use in the power sector diminishes (Figure 4.1). Oil rebounds from its crisis-hit lows, and then grows slowly to reach 103 million barrels per day (mb/d) around 2030, then gradually declines to 96 mb/d by 2050 as reductions in road transport oil demand are partly offset by higher oil use for petrochemicals and kerosene for aviation. Natural gas demand grows by 480 billion cubic metres (bcm) to 2035, or 1% per year, driven by growth in industry, the power sector and transport, and then plateaus at around 4 800 bcm until 2050.

Figure 4.1 ▷ Total energy demand by fuel and region in the STEPS, 2015-2050



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Each fossil fuel peaks or plateaus in the next decade before renewables take over; emerging market and developing economies outside China lead demand growth

Notes: EJ = exajoule; C & S America = Central and South America. Other includes traditional use of biomass and non-renewable waste.

In aggregate, renewables see the largest increase in demand. Over the next decade, renewables demand rises by about 55 EJ in the STEPS, which is more than the increase in total energy demand. Together with a strong recovery in nuclear additions, this growth displaces 26 EJ of coal demand, mostly in the power sector. In end-use sectors, electricity meets most consumption growth. Oil and natural gas accounted for more than half of end-use demand growth over the last decade, but their combined contribution falls to around 25% in the period to 2035 as electric vehicles (EVs), heat pumps and industrial electrification gain ground.

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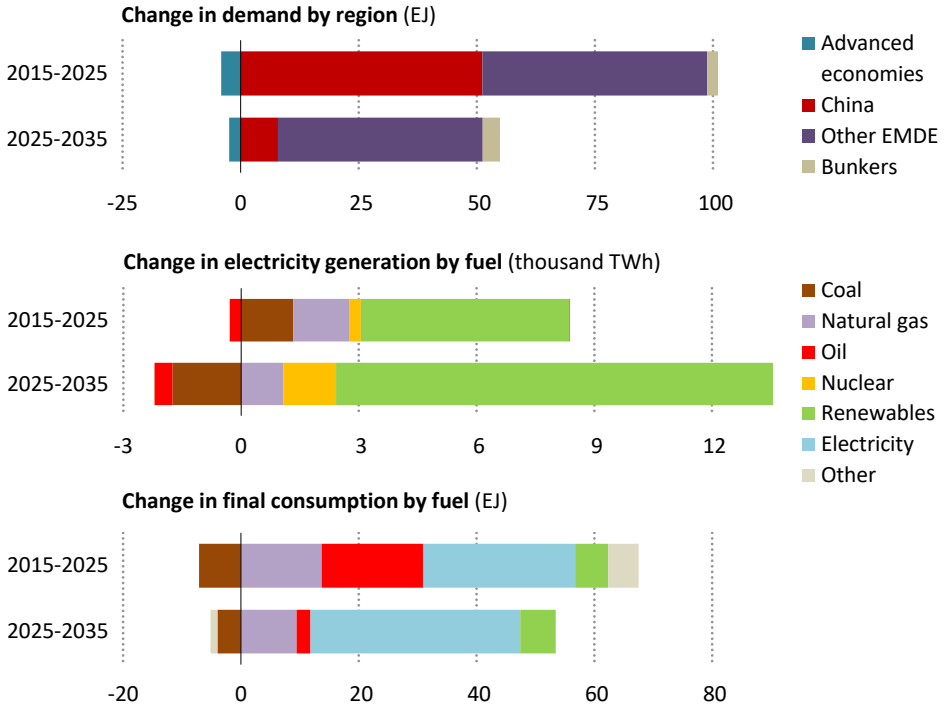
Figure 4.2 ▷ Change in primary energy demand, electricity generation and final consumption by region and by fuel in the STEPS, 2025-2035



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EMDE outside China account for most demand growth to 2035; renewables accelerate as electrification sets the pace, displacing coal and edging down oil

Notes: TWh = terawatt-hour; EMDE = emerging market and developing economies. Other includes district heat, traditional use of biomass, non-renewable waste and hydrogen.

Centres of demand growth also shift in the next decade in the STEPS. As in the last decade, energy demand from advanced economies is broadly stable as higher activity is offset by efficiency gains and electrification (Figure 4.2). China accounted for more than half of the increase in global energy demand over the last decade, but its demand growth slows markedly in the coming years as changes in economic structure, electrification and the deployment of renewables offset much of the impact of continued economic expansion. Emerging market and developing economies outside China account for the majority of global demand growth over the next decade, led by India, Southeast Asia and parts of the Middle East and Africa, all of which see energy demand increase by 15-30%. While these trends are consistent with the *World Energy Outlook 2025* (*WEO-2025*) STEPS, the *WEO-2026* STEPS reflects energy, market and policy developments that unfolded this year and reshape the outlook (Box 4.1).

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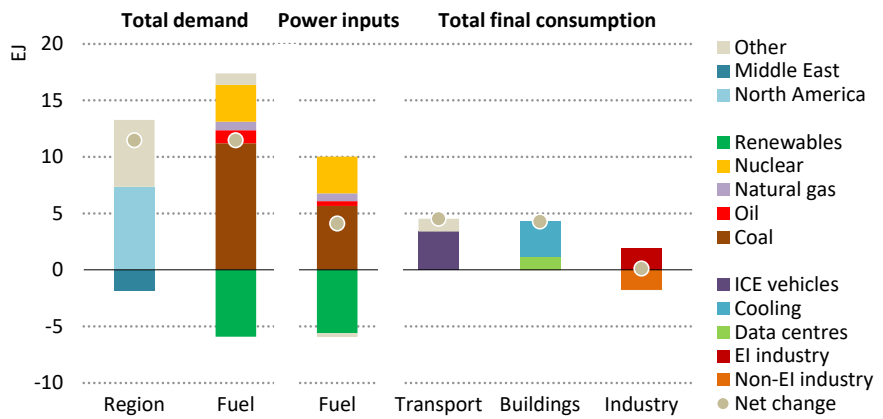
Box 4.1 ▷ What has changed in this year's STEPS?

The STEPS is updated annually to reflect changes in policies, market dynamics and technological advancements, and it is instructive to examine how this year's projections differ from those in the *WEO-2025*. The disruption in global energy trade precipitated by the conflict in the Middle East and the resulting impact on GDP and industrial activity have left their mark on this year's projections. There have also been other changes since the 2025 edition of the STEPS. Taken together, these have led to several revisions in the *WEO-2026* STEPS (Figure 4.3):

- Higher electricity demand: Electricity demand in 2035 is higher by 1 300 terawatt-hours (TWh), or 3%, than in the *WEO-2025* STEPS. This is due to several factors. Recent heatwaves led to an upward revision of AC penetration rates in the outlook. More data centres are now set to be installed than envisaged last year, notably in the United States. Some countries also took immediate policy action to support electrification following the onset of the 2026 energy crisis (see Chapter 2).
- Renewables: Curtailment is excluded from electricity generation by technology for the first time in *WEO-2026* and shown separately (see Annex A). This methodological change means that the reported renewables generation reflects the direct contribution to meeting demand rather than what is available. The change explains nearly all of the reduction for renewables seen in the 2026 STEPS; without it, renewables would be within 3% of the *WEO-2025* STEPS results in 2035.

Figure 4.3 ▷ Differences in global energy demand in the *WEO-2026* STEPS relative to the *WEO-2025* STEPS, 2035



The main changes affect North America and the Middle East; they reflect the effects of the 2026 energy crisis, responses to it and other policy changes

Note: ICE = internal combustion engine; EI = energy-intensive.

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- Evolving policy and market backdrop: Oil demand in transport is higher than in the *WEO-2025* STEPS, particularly in North America and, to a lesser extent, in the European Union, driven by a downward revision of EV sales. This reflects recent policy changes, such as the expiration of EV tax credits in the United States and the inclusion of the Automotive Package in the European Union announced in December 2025. These effects are partly offset by stronger electric car uptake in other regions where cost competitiveness grows, including Latin America and Southeast Asia, and by the faster electrification of trucks in China. Nuclear benefits from strong momentum globally, and its output is 8% higher in 2035 than in the *WEO-2025* STEPS, with much of the increase taking place in China, Europe and the United States.

4.2.2 CO_2 emissions

Energy-related carbon dioxide (CO_2) emissions totalled 38.7 gigatonnes (Gt) in 2025. In the STEPS, energy-related CO_2 emissions peak before 2030 and then decline to around 36 Gt CO_2 by 2035 and around 30 Gt CO_2 by 2050. This means that emissions fall back to around 2017 levels by 2035 despite the global economy expanding by 70% between 2017 and 2035. The largest relative reductions are in the European Union, Australia, New Zealand, Japan and Korea, where CO_2 emissions fall by roughly 30% over the next decade. These reductions are supported by major policy frameworks such as coal phase-out commitments specified by 14 EU member states and measures to reduce inefficient coal-fired generation under Japan's 7th Strategic Energy Plan. In the United States, CO_2 emissions continue to decline by less than 1% per year, which is roughly the same rate seen over the past decade. Emissions in China peak before 2030 and then see the largest absolute decline of any region, falling by 1.9 Gt CO_2 to 2035. In India, CO_2 emissions do not peak until around 2040 and then begin to decline slowly to 2050.

A move away from coal-fired power generation accounts for more than 90% of the global reduction in CO_2 emissions over the next decade (Figure 4.4). China is responsible for around half of this reduction and advanced economies for 45%, with coal-fired generation falling by 20% and 55% in these regions, respectively. Emissions from cars decline by almost 10% over the next decade. CO_2 emissions from energy-intensive industry rise in most regions, but these increases are offset by declines in China, where iron, steel and cement production falls.

Global energy-related methane emissions in the STEPS decrease from 150 million tonnes (Mt) today to 120 Mt in 2035. Warming in the STEPS exceeds 2 °C by around 2060 and reaches around 2.5 °C by 2100 (with a 50% probability), broadly in line with the 2025 edition of the STEPS.

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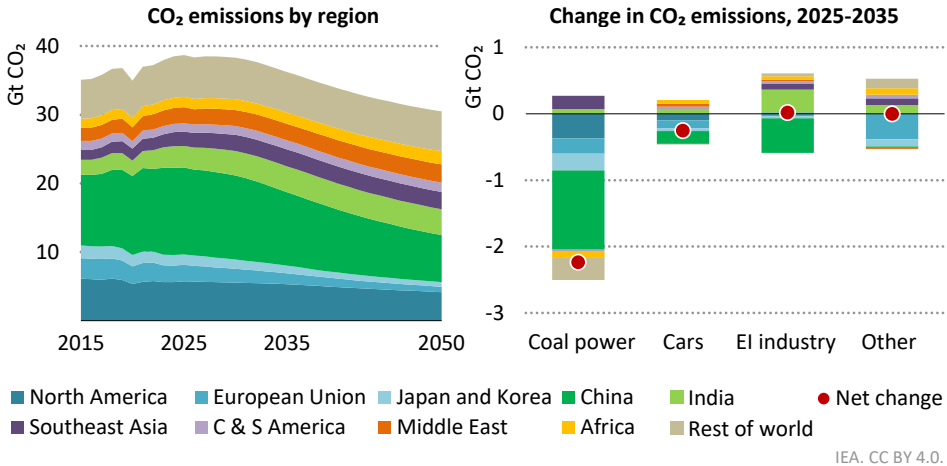
Figure 4.4 ▷ Global CO_2 emissions and change by region and sector in the STEPS, 2015-2050



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Declining coal-fired power generation drives CO_2 emissions reductions, particularly in China and advanced economies

Notes: Gt CO_2 = gigatonnes of carbon dioxide. Other includes power generation excluding coal generation, buildings, shipping, aviation, freight and non-energy-intensive industries.

4.3 Total final consumption

Global total final consumption (TFC) – the energy consumed by end-users – reached 466 EJ in 2025 after growing by 1.4% per year on average since 2015. In the STEPS, it rises to 514 EJ by 2035, and growth slows to 1.0% per year as electrification accelerates and the equipment stock becomes more efficient. TFC has expanded at a broadly similar rate in the industry, transport and buildings sectors since 2015, and growth slows in all three to 2035.

In 2025, electricity accounted for 23% of total final energy consumption (TFEC) – excluding non-energy use – but the extent to which it was used varied widely between sectors, with electrification rates of 39% in buildings, 27% in industry and 2% in transport. By 2035, electricity accounts for about 29% of global TFEC in the STEPS, and the electrification rate rises to 48% in buildings, 31% in industry and 6% in transport.

Electrification changes the relationship between final energy consumption and useful energy – the energy services delivered to consumers (Figure 4.5). Most conventional equipment operates by burning fuels and involves significant energy losses. For example, the average efficiency of an internal combustion engine (ICE) vehicle is around 25-35%. As a result, the useful energy delivered to end users is well below the final energy consumed, especially in transport, in which it is 35% of final consumption. Electric technologies are generally much more efficient than conventional alternatives: heat pumps are typically three to five times more efficient than boilers, while EVs are around three times more efficient than ICE vehicles.

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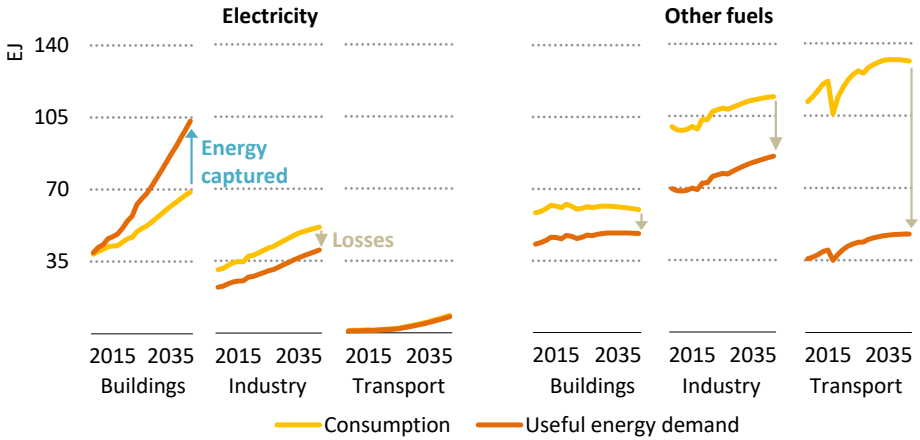
Figure 4.5 ▷ Sectoral energy consumption and useful energy demand from electricity and other fuels in the STEPS, 2015-2035



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Both energy consumption and useful energy demand grow over time; electricity delivers more useful energy per unit of energy consumed than other fuels

Notes: Energy captured refers to energy transferred to and from the environment through equipment with an efficiency higher than 1, such as heat pumps and ACs. Useful energy refers to the service received by the consumer, after accounting for the equipment losses (or gains in the case of heat pumps or ACs). The arrows indicate the net effect of losses or energy captured by sector. In this figure, buildings and industry exclude traditional use of biomass and non-energy use, respectively, for both useful energy demand and final consumption.

These efficiency gains mean that useful energy grows faster than final energy consumption as electrification progresses. In buildings, the growing use of ACs and heat pumps, which deliver heating and cooling by transferring heat to and from the surrounding environment, means that by 2035, the sector delivers more useful energy than the final energy it consumes. By that date, almost 70% of useful energy in buildings is met by electricity. In transport, electricity accounts for 14% of useful energy by 2035 in the STEPS, more than twice its share in final consumption. In non-energy-intensive industries, industrial heat pumps offer similar benefits, but their uptake remains too limited in the STEPS to deliver large savings by 2035. At higher temperatures, the efficiency of electric technologies is reduced to a level much closer to that of conventional fuel-based technologies.

4.3.1 Transport

Transport sector energy demand reached 130 EJ in 2025 and has risen by around 15% since 2015. Demand growth was concentrated in China, India, Southeast Asia, and Africa, with passenger cars and road freight each responsible for around one-third of the increase. Transport accounts for 28% of TFC today, and this declines slightly to 27% by 2035 in the STEPS. Oil met 89% of transport energy demand in 2025; this falls by eight percentage points by 2035, largely on the back of road transport electrification (Figure 4.6).

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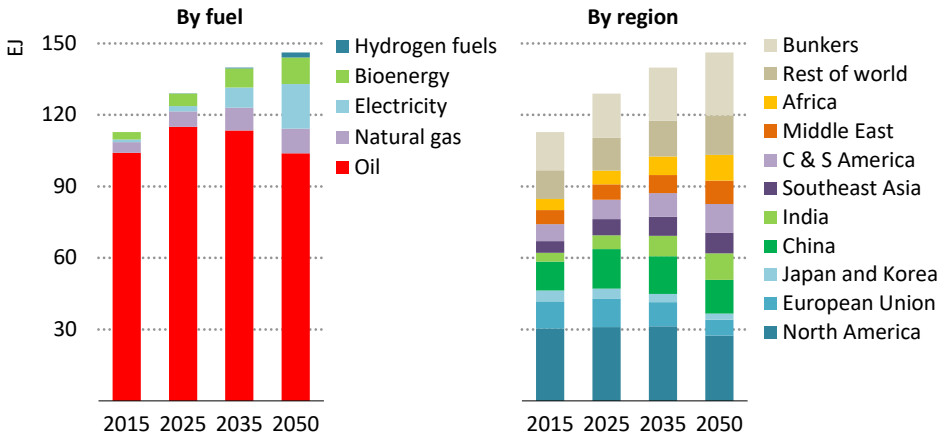
Figure 4.6 ▷ Transport final energy demand by fuel and by region in the STEPS, 2015-2050



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The share of oil in transport energy demand declines from 92% in 2015 to 81% in 2035; North America accounts for nearly a quarter of global transport energy demand in 2035

Notes: Bunkers include international marine and aviation energy consumption. Hydrogen fuels include hydrogen and hydrogen-based fuels.

Global electric car sales increased by 20% in 2025, accounting for a quarter of total car sales. China remained the primary engine of EV sales growth, with EVs – battery electric and plug-in hybrid vehicles – accounting for nearly 55% of car sales. In the European Union, electric car sales rose by almost a third in 2025 to take a 27% market share. The share of car sales taken by EVs is increasing further in many markets in 2026, with more affordable models and higher gasoline prices boosting interest from buyers. Electrification is making progress in other parts of the market for vehicles as well: sales of electric trucks, buses and two/three-wheelers all increased in 2025 and are continuing to rise in 2026. If higher oil prices persist, the payback period for an electric car could be 20% shorter on average, further improving cost competitiveness.

EVs are not alone in challenging the dominance of oil in the road transport market. Natural gas vehicles remain competitive where their fuel cost advantages are strongest, with compressed natural gas cars in India and LNG heavy freight trucks in China accounting for nearly 20% and 30% of sales, respectively, in 2025. Meanwhile, higher blending mandates and energy security priorities increased biofuel consumption in 2025 by around 50% in India, 40% in Japan, 10% in Southeast Asia and 5% in Europe.

In the STEPS, transport electrification gains further ground over the next decade. Car ownership in the European Union, North America, and Japan and Korea changes by up to 3% to 2035, while electric car sales shares rise two to five times. In India, Southeast Asia, and

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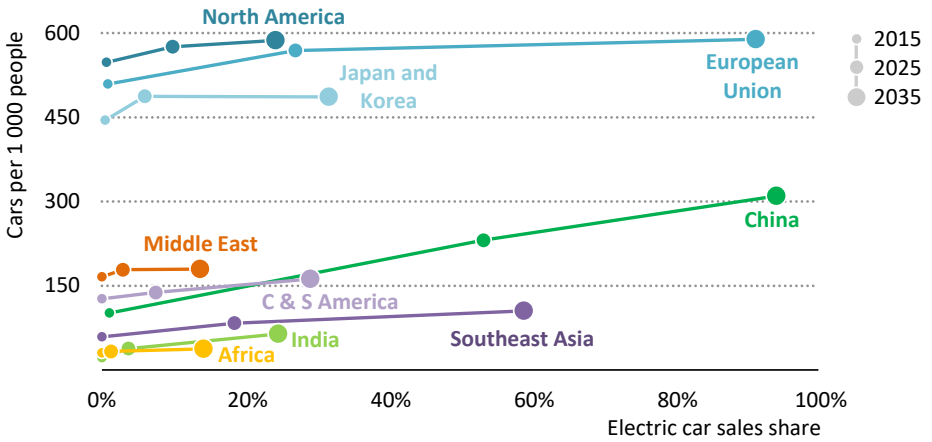
Central and South America car ownership grows by around 70%, 25% and 15%, respectively, by 2035, while electric car sales shares are three to seven times higher. China remains an outlier, with electric car sales taking a market share of over 90% by 2035 as car ownership increases by a third (Figure 4.7). Globally, electric car sales account for 55% of total car sales by 2035 in the STEPS. However, the pace of car fleet turnover can have significant implications for how this outlook evolves (Box 4.2).

Figure 4.7 ▷ Car ownership rate and electric car share in new sales by region in the STEPS, 2015-2035



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Electric car adoption accelerates across all regions by 2035, while the growth in car ownership is fastest in India and China

Box 4.2 ▷ How price crises reshape car purchase decisions

Economic uncertainty can cause consumers to delay buying new cars, thus keeping older, less efficient cars on the road for longer. This matters for energy markets: cars account for over 20% of global oil demand, and new car fuel efficiency has improved by more than 10% since 2015. Slower fleet turnover can delay not only the adoption of EVs but also the benefits of the efficiency gains offered by new ICE cars, slowing near-term reductions in oil demand and the pace of the energy transition.

Globally, around one-third of new car sales today add to the total car fleet, while the remaining two-thirds replace cars that are retired from the fleet. In 2025, cars aged 15 years and older accounted for around 15% of total car emissions. Countries including China, France and Germany have used scrappage and fleet-renewal schemes to accelerate retirement of older, less efficient vehicles. Schemes of this kind can be particularly effective when weak consumer confidence and high financing costs are delaying car replacement.

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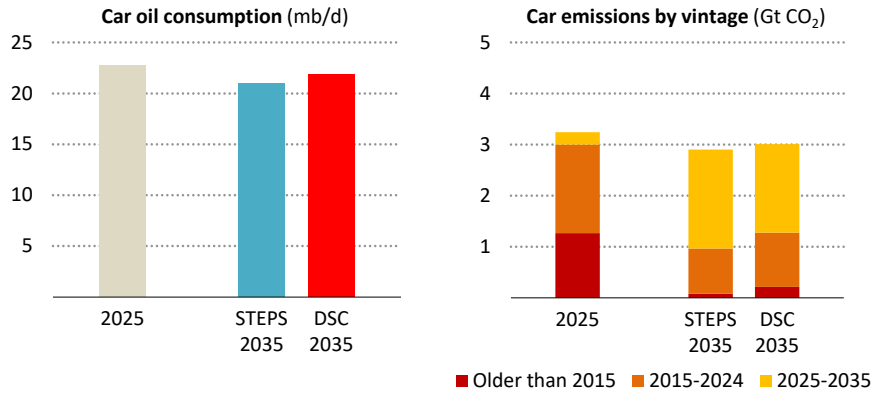
Figure 4.8 ▷ Car oil consumption and emissions by vintage in the STEPS and Delayed Scrappage Case, 2025 and 2035



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Energy and economic shocks affect transport demand and electrification trends, with oil demand reductions nearly 1 mb/d smaller by 2035 if cars are owned 10% longer

Note: mb/d = million barrels per day; DSC = Delayed Scrappage Case.

Price crises can extend vehicle lifetimes by reducing scrappage and delaying replacement. Car sales in the United States fell by over 5 million between 2007 and 2009, when the financial shock pushed the economy into a deep recession, while the country's car stock declined by only 1.5 million as consumers delayed replacing their cars. Scrappage fell by 500 000 vehicles in 2008 (United States, Bureau of Transportation Statistics, 2016). The average age of newly purchased cars rose from 5.5 years in 2005 to 6.8 years in 2012 (Federal Reserve Bank of St. Louis, 2018).

In the STEPS, global oil demand from cars falls by 1.8 mb/d by 2035 from around 23 mb/d today, while emissions decline from just under 3.2 Gt CO_2 to 2.9 Gt CO_2. In a delayed scrappage case, in which car owners keep their cars 10% longer by 2035 than they currently do before replacing them with a new model, oil demand would instead fall by around 900 thousand barrels per day (kb/d) and emissions by over 200 Mt CO_2 from today's level (Figure 4.8). By 2035, cars aged ten years and older would account for more than half of the global fleet, compared with less than 45% in the STEPS, while fleet fuel economy would improve by over 15%, instead of more than 20% in the STEPS. In both cases, however, cars bought in the next ten years account for the majority of car emissions by 2035.

A combination of regulation, information and incentives can help prevent economic downturns from slowing fleet efficiency gains. Targeted, time-bound scrappage and trade-in schemes can accelerate the retirement of the oldest vehicles, while fuel-economy and CO_2 standards help to increase the efficiency of new vehicles.

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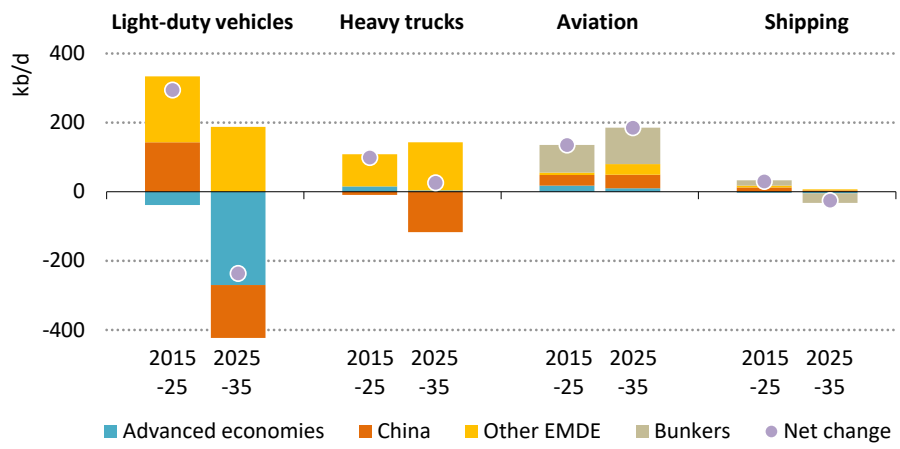
Road light-duty vehicles, mainly cars, have added 300 kb/d of oil demand annually since 2015 and now consume 28 mb/d, while heavy trucks, which include medium freight and heavy freight trucks, have added 100 kb/d annually and now consume 13 mb/d. In the STEPS, electrification and efficiency gains reshape oil demand (Figure 4.9). Electricity's share of road energy demand rises from 1% today to 7% by 2035, putting road oil demand into decline. Light-duty vehicle oil demand falls by over 230 kb/d annually to 2035, driven by advanced economies, despite passenger car activity growing by a quarter globally. Freight activity grows by over 25%, but an improvement of around 10% in energy intensity limits heavy truck oil demand growth to about 25 kb/d annually.

Figure 4.9 ▷ Annual oil demand change by transport mode in the STEPS, 2015-2035



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Oil demand growth becomes increasingly concentrated in aviation as electrification and alternative fuels reshape road transport and shipping

Notes: kb/d = thousand barrels per day. Light-duty vehicles include passenger cars and light commercial vehicles. Heavy trucks include medium freight trucks and heavy freight trucks. Bunkers include international marine and aviation oil demand.

Rail is already the most electrified transport mode, with electricity meeting almost half of its energy consumption; in the STEPS, this share rises towards 55% by 2035. Oil use has increased by 3 kb/d a year since 2015 and now stands at less than 650 kb/d. It declines by 2 kb/d a year to 2035 in the STEPS, even as passenger and freight rail activity grow by around 35% and 15%, respectively.

Shipping relies firmly on oil today, accounting for around 92% of its energy consumption. Oil demand stands at more than 5 mb/d after rising by 30 kb/d a year over the past decade. It declines by 5% by 2035 in the STEPS, but the share of demand met by oil falls to just over 80% as other fuels gain ground. LNG accounts for 16% of the fuel mix in 2035; bioenergy, methanol, hydrogen and ammonia together account for 3%; and electricity for less than 1%.

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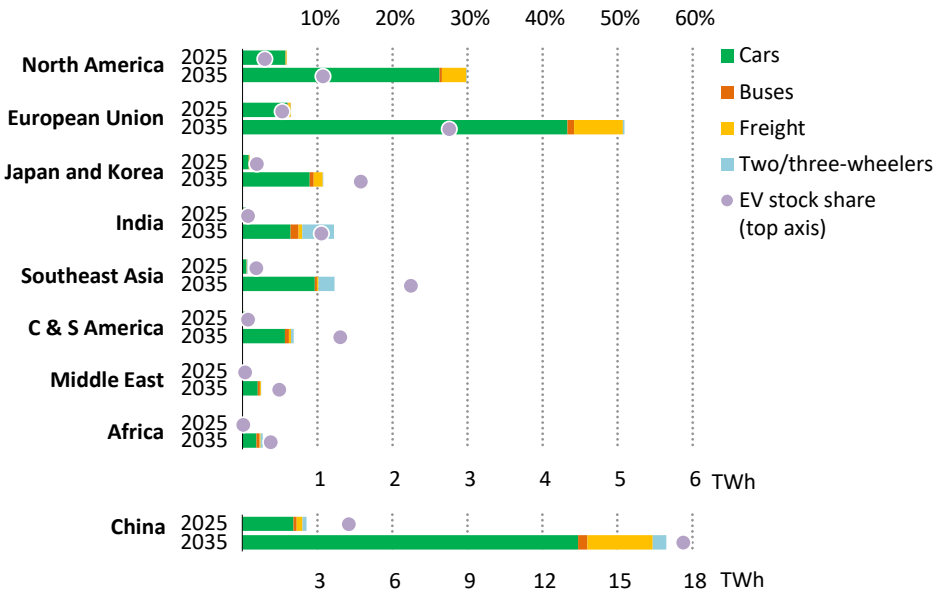
Aviation remains the most oil-dependent mode of transport in the STEPS. Oil use has risen by 135 kb/d a year over the past decade to reach close to 7.5 mb/d today, and it continues to rise in the STEPS to 2035 as passenger travel expands by 45%, outpacing efficiency gains of nearly 1% a year. Sustainable aviation fuel takes close to 5% of the aviation fuel market by 2035 thanks to EU and UK mandates, but aviation remains one of the main sources of global oil demand growth, with consumption rising by 185 kb/d a year to 2035.

Figure 4.10 ▷ EV battery volumes in use by vehicle type and region and share of EVs in total stock by region in the STEPS, 2025 and 2035



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Future battery deployment is dominated by passenger cars, but two/three-wheelers play a key role in EMDE, and freight gains ground in advanced economies and China

Note: EV = electric vehicle.

In the STEPS, the global share of sales from EVs across all vehicle modes rises from nearly 20% today to more than 50% in 2035, raising the EV share of the global road vehicle stock from around 5% in 2025 to 25%, with China remaining the main driver of growth (Figure 4.10). Public charging capacity more than quadruples by 2035, supported by investment in grids and charging equipment. Emerging market and developing economies outside China increasingly benefit from used EV imports, which rise to around 400 000 by 2035. This boosts the electric car stock share in these economies from 1% to 10%, although affordability remains a constraint.

EV battery deployment diverges sharply by region in the STEPS. In China, EV fleet battery volumes in use rise sevenfold between 2025 and 2035 to 17 TWh, which is nearly equivalent to all other regions combined. In the European Union, they rise to 5 TWh. Deployment

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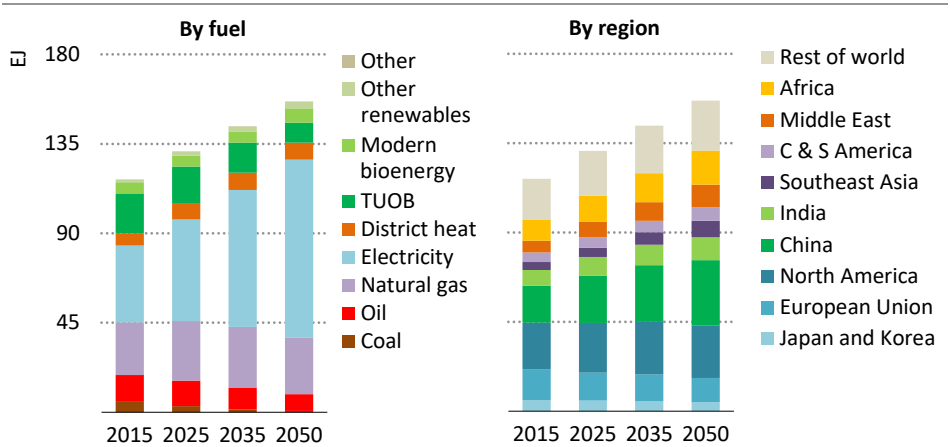
remains lowest in the Middle East and Africa. Passenger cars remain the largest source of battery deployment globally. Freight electrification is the second fastest-growing contributor in advanced economies and China, adding almost 4 TWh by 2035 in the STEPS. In emerging market and developing economies outside China, two/three-wheelers add 0.7 TWh, with India accounting for one-third of global battery volumes in use by 2035.

4.3.2 Buildings

Energy demand in the buildings sector reached over 130 EJ in 2025 after growing at an average annual rate of 1.1% since 2015. In the STEPS, growth slows to 0.9% per year to 2035. Coal and oil use in buildings continues to decrease, falling each year on average by 7% and 2%, respectively, to 2035 (Figure 4.11). Most of the decline in coal use is concentrated in China. Oil use, especially liquefied petroleum gas (LPG), rises over the next decade in Africa, India and Southeast Asia as access to clean cooking expands, even as the 2026 energy crisis prompts greater uptake of electric cooking and efforts to diversify cooking fuels (Box 4.3). Natural gas consumption plateaus: it has increased by 1.3% annually since 2015, but growth slows to 0.2% per year to 2035 as electrification and efficiency improvements curb heating demand in advanced economies. The traditional use of biomass continues to decline as modern energy services become more widely available, and around 640 million people gain access to clean cooking by 2035. The direct use of renewables, mainly modern bioenergy and solar thermal, grows by 0.9% annually to 2035, driven by the expansion of low-emissions heat.

Figure 4.11 ▷ Energy demand in buildings by fuel and by region in the STEPS, 2015-2050



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Electricity meets a growing share of increasing buildings energy demand as fossil fuels enter structural decline

Notes: TUOB = traditional use of biomass; Other renewables = solar thermal and geothermal. Other includes non-renewable waste and hydrogen.

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Box 4.3 ▷ How the 2026 energy crisis is reshaping cooking demand

Around 3.5 billion people across the developing world cook with LPG, and many countries rely heavily on imports to provide it. During the 2026 energy crisis, LPG flows through the Strait of Hormuz fell by 80%, dropping from 1.5 mb/d to 0.3 mb/d. Almost all these exports had been destined for Asia. India's total LPG imports fell by more than half during the first two months of the crisis, while LPG index prices rose by 70-100% across Africa and developing Asia (IEA, 2026a).

Consumers responded according to the alternatives available locally. Households with a reliable and sufficiently large electricity connection and the means to afford induction cookstoves bought them, with sales in India rising more than tenfold year-on-year in the first quarter of 2026 (IEA, 2026b). Increased population movement from cities to rural areas was also reported in India, reflecting expectations of easier access to wood and charcoal for cooking.

Governments of the worst-hit countries took immediate action. The IEA has tracked 23 cooking fuel measures implemented since the beginning of the energy crisis, most with a short-term focus on the prioritisation of cooking fuels and on affordability support, such as tax exemptions and increased subsidies.

Other policy interventions have focused on improving LPG supply chain resilience and diversifying the cooking fuel mix, which could have more structural long-term impacts. India's National PNG Drive 2.0 campaign is accelerating natural gas pipeline development and last-mile connections, and it has connected more than 1.2 million households to the natural gas network since March 2026 (India, Ministry of Petroleum and Natural Gas, 2026). The Cambodian government reduced import duties on electric stoves from 35% to zero (Royal Government of Cambodia, 2026). Indonesia's 2027 budget includes USD 52 million for an electric cookstove programme and USD 316 million for city gas networks (Indonesia, Ministry of Energy and Mineral Resources, 2026).

In the STEPS, the cooking fuel mix becomes more diverse over time. In emerging market and developing economies, electricity consumption for cooking grows by almost 70% to 390 TWh by 2035. The use of natural gas for cooking also increases by 28% to 2.2 EJ, although it continues to play a relatively minor role in the overall cooking fuel mix. Despite these shifts, LPG remains essential to the expansion of clean cooking, since the majority of LPG growth is concentrated in places where electricity can be unreliable and natural gas infrastructure is unavailable.

Over 90% of buildings energy demand growth in the STEPS takes place in emerging market and developing economies, which account for the majority of additions to global floorspace and the stock of appliances (Figure 4.12). By 2035, residential floorspace expands by almost 40 billion square metres, the stock of ACs grows by 45%, and the appliance stock expands by 2 billion units. China drove most of the AC stock increase in the last decade, and its use of ACs continues to grow over the next decade. However, the outlook identifies new regional

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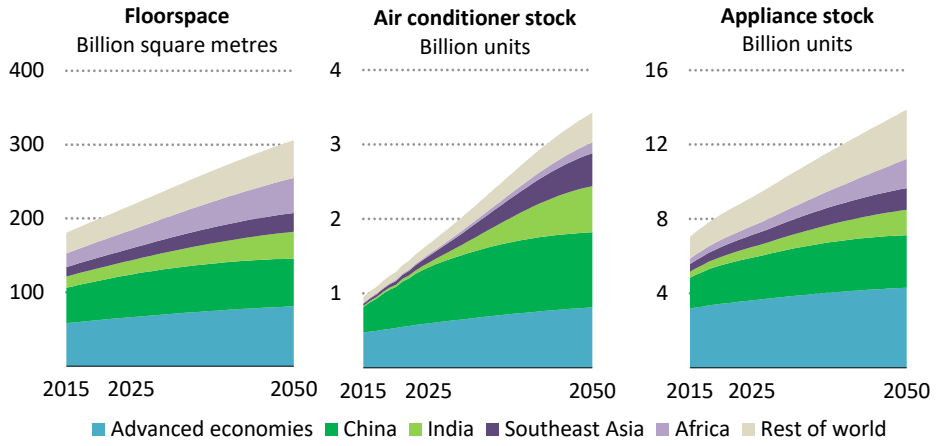
centres of growth: the share of India and Southeast Asia in the stock of ACs rises from less than 10% today to 20% by 2035. More frequent and intense heatwaves could further accelerate AC uptake and use, particularly in countries with low ownership today (Box 4.4).

Figure 4.12 ▷ Key residential energy demand drivers by region in the STEPS, 2015-2050



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India and Southeast Asia become increasingly important centres of floorspace and household appliance growth, particularly for air conditioners

These trends increase the global electrification rate in buildings from 39% today to 48% by 2035. Electricity demand for buildings increases in the STEPS by almost 5 000 TWh to 2035, growing more than three times as fast as the sector's overall energy demand. In addition to powering appliances and space cooling, which account for more than 60% of buildings' electricity demand today, electricity also meets most of the net demand growth for space heating, water heating and cooking (Figure 4.13). The share of electric technologies in the sales of equipment has risen since 2015 across end-uses, and it is set to continue increasing to 2035, supported by electrification policies in some regions and by the growing cost competitiveness of electric technologies.

Global heat pump sales in 2025 remained at broadly the same level as in 2024, accounting for around 110 gigawatts (GW) of capacity. In the European Union, following a decline in sales in 2024, the heat pump market rebounded by 12% in 2025 and has continued to expand in the first half of 2026. Global heat pump sales almost double in the STEPS by 2035; this reflects clean heat requirements in parts of Europe and the ability of heat pumps to compete effectively in markets in China, Japan and the United States, where the cost competitiveness of air-to-air units is boosted by their ability to meet both heating and cooling needs. Continued government subsidies, meanwhile, support growing sales of air-to-water heat pumps in regions where they are not competitive today. Based on regional upfront costs for

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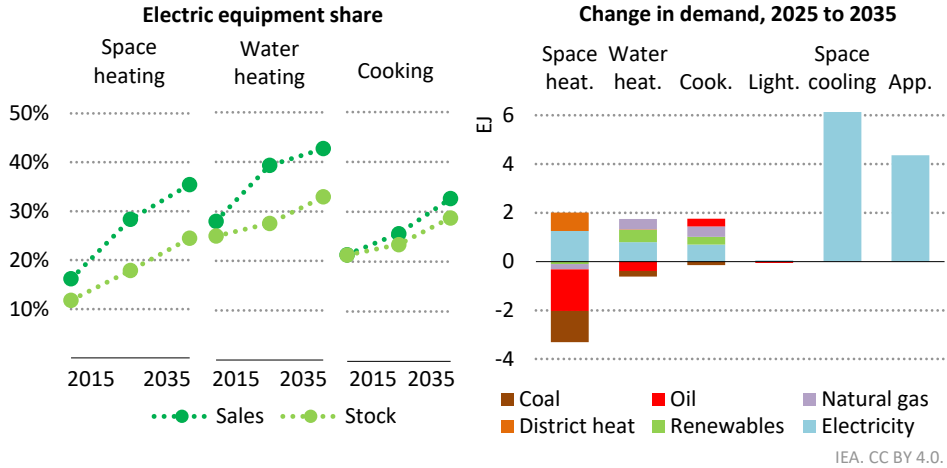
heat pumps and boilers, fuel prices and finance costs, IEA analysis finds that heat pumps are now competitive for half of global heating demand. However, stable policies and financial support are needed to maintain consumer confidence and allow sales growth to materialise.

Figure 4.13 ▷ Share of electric equipment by end-use and change in demand by fuel and by end-use in the STEPS, 2015-2035



Electrification grows across end-uses, with electric equipment sales shares rising by 10-20 percentage points in 2035 from 2015 levels; electricity displaces fossil fuel consumption

Notes: Heat. = heating; Cook. = cooking; Light. = lighting; App. = appliances. Cooking excludes traditional use of biomass.

Box 4.4 ▷ Cooling a hotter world: will heatwaves push demand higher?

AC ownership levels vary greatly between countries. In some advanced economies, such as Australia, Japan and the United States, around 90% of households own at least one AC today. In India and Indonesia, by contrast, fewer than one in five households own an AC, despite high cooling needs. In the STEPS, rising incomes, greater AC ownership and higher temperatures cause demand for space cooling in buildings to rise by 1 700 TWh by 2035, an increase roughly equivalent to India's total electricity demand today. As a result, global space cooling demand rises to 4 700 TWh (Figure 4.14).

Record temperatures and heatwaves in recent years have contributed to strong AC sales both in European countries with historically limited cooling needs and in emerging market and developing economies where sales were already rising. The STEPS takes into account the likely effect of long-term increases in average temperatures on AC demand and use, but *WEO-2026* also explores a heatwave case in which stronger, more frequent and longer heatwaves raise levels of both AC ownership and use. In this heatwave case, global cooling demand growth is 700 TWh higher in 2035 than in the STEPS, an increase of 40%.

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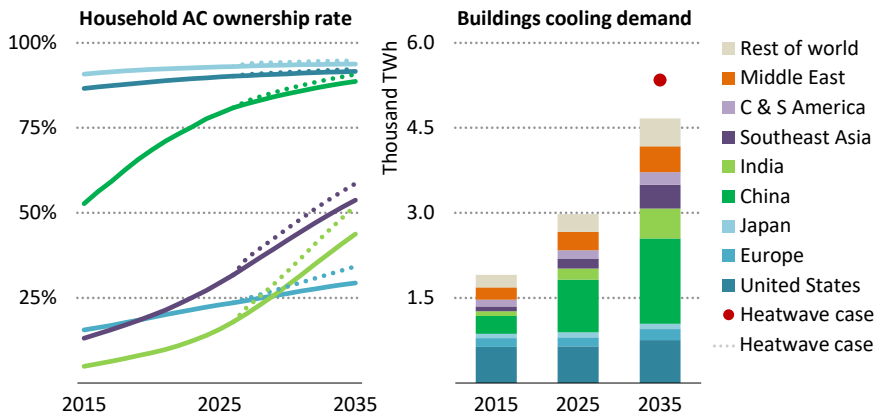
Figure 4.14 ▷ Share of households owning an air conditioner and buildings cooling demand in the STEPS and heatwave case, 2015-2035



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Rising AC ownership drives surging demand for space cooling; more intense heatwaves could lead to 700 TWh of additional cooling demand by 2035

Notes: The heatwave case reflects a world in which more frequent, more intense and longer heatwaves mean that levels of cooling demand in aggregate are higher than in the STEPS, considering a higher share of AC adoption in countries that have historically had low cooling needs, and an accelerated uptake in countries that were already on course to see their AC ownership rates grow.

Appliance efficiency gaps are narrowing at different speeds

Appliances sold in advanced economies and China are generally more efficient than those sold elsewhere, reflecting higher consumer purchasing power, earlier uptake of efficient technologies and more widespread and stringent minimum energy performance standards (MEPS). However, the pace of convergence differs by appliance category. Efficiency gaps have already narrowed for televisions and light-emitting diodes (LEDs), supported by globalised supply chains, concentrated manufacturing and common product platforms (Figure 4.15). Once firms have invested in efficient components and product architectures for televisions in major regulated markets, it is cheaper to use the same platform globally than to maintain separate lower-efficiency designs for smaller or less regulated markets. Convergence towards highly efficient lighting has also been supported by strong policies in several major markets. Without the efficiency gains made in lighting, televisions, refrigeration and cleaning appliances over the past decade, electricity demand in 2025 would have been 600 TWh higher.

For refrigerators and washing machines, global scale has not led to the same convergence around common, highly efficient product platforms. Regional differences in regulation, consumer preferences and price sensitivity continue to support distinct product designs and efficiency levels. Space cooling shows some signs of manufacturing consolidation, but further convergence around more standardised, high-efficiency product designs will depend in part

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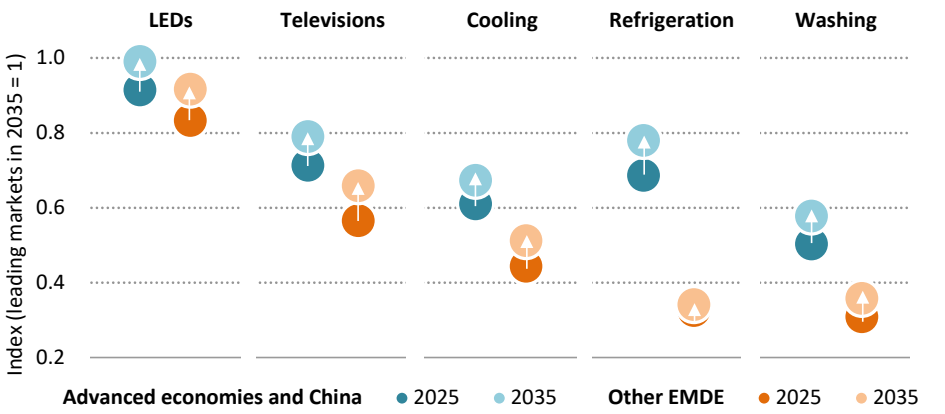
on regulatory choices in emerging market and developing economies, as well as in major manufacturing hubs. Some countries, including Côte d'Ivoire, Ghana and Nigeria, have introduced restrictions on second-hand appliance imports to limit inflows of inefficient products. In 2026, China, the world's largest exporter of ACs, introduced an energy performance grading standard for room ACs destined for export.

Figure 4.15 ▷ Efficiency of residential appliance sales by region in the STEPS, 2025 and 2035



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Average efficiency levels of LEDs and televisions are converging globally, while efficiency gaps remain wider for refrigeration and washing equipment

Notes: LEDs = light-emitting diodes. Leading market refers to the country with the highest efficiency of sales for the respective appliance in 2035.

In the STEPS, the rate of efficiency improvement continues to vary across appliances, reflecting differences in market trends and stated policies. By 2035, televisions sold in emerging market and developing economies outside China are 16% more efficient than today, and LEDs are 10% more efficient. Refrigerator efficiency advances more slowly, rising by 5% in the same period. Across household appliance categories – lighting, televisions, cleaning appliances and refrigerators – efficiency improvements in the STEPS avoid almost 200 TWh of electricity demand per year by 2035. Aligning MEPS in all countries with the most stringent established standards in force today would unlock an additional 800 TWh of savings by 2035, almost half of which comes from refrigerators alone.

4.3.3 Industry

The industry sector – which covers manufacturing, mining, quarrying and construction – accounted for 38% of TFC in 2025, making it the largest of the end-use sectors in terms of energy demand. Global industrial coal use totalled 1 600 Mtce in 2025, which was 170 Mtce lower than in 2015. Chinese industrial coal use – the largest single fuel use in any country, in

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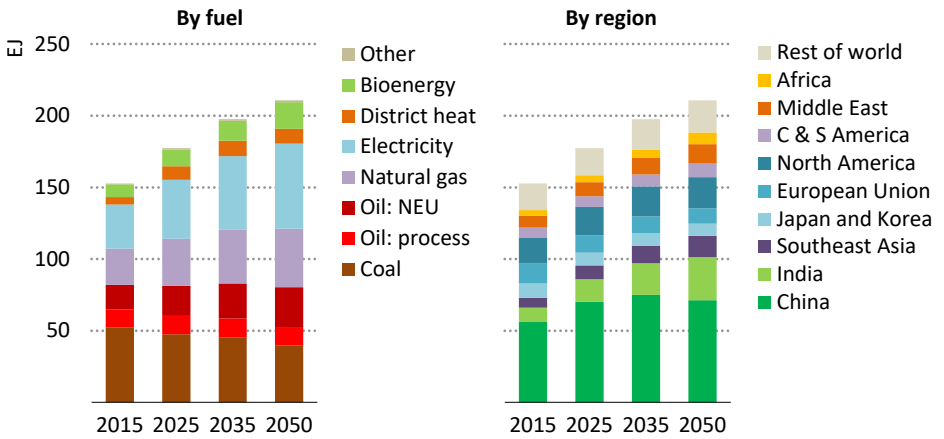
any end-use sector – declined over the last decade by 225 Mtce, more than offsetting growth in India and Southeast Asia (Figure 4.16). The use of virtually all other fuels in industry has grown in the last decade, led by electricity (accounting for 35% of the gross increase), followed by natural gas (25%), oil and district heat (14% each) and bioenergy (10%). Hydrogen, geothermal and solar thermal collectively account for less than 0.1% of industrial energy use.

Figure 4.16 ▷ Energy demand in industry by fuel and by region in the STEPS, 2015-2050



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The share of fossil fuels in industrial demand declines from 70% in 2015 to 61% in 2035; China remains a stronghold, accounting for around 40% of global industry energy demand in 2035

Notes: NEU = non-energy use. 'Other' fuel includes hydrogen, non-renewable waste, solar thermal and geothermal. Non-energy use of coal, natural gas and bioenergy is not displayed separately.

In the decade to come, industrial electrification continues to gain ground, with most of the 2 500 TWh increase in demand in the STEPS occurring in non-energy-intensive industries, notably in the food and machinery sectors. Although this trend is common to all regions, it is strongest in emerging market and developing economies. Industrial electricity demand is also boosted by hydrogen produced via electrolysis inside industry facilities, especially in the chemicals sector; most of this increase takes place in China and the European Union. With plastics demand increasing, industrial use of oil continues to grow, mostly in the chemicals sector: in 2035, almost 70% of the 23 mb/d industrial oil demand is for chemical feedstocks. Industrial natural gas demand is also on the rise, but its 2035 use has been revised geographically compared to the *WEO-2025* STEPS, with reductions in the Middle East, Southeast Asia (Box 4.5) and India, partly offset by increases in North America and Russia. This revision mainly occurs in the chemicals sector, with changes in fertiliser production locations. Even though cement and steel production continue to increase globally, industrial coal consumption declines over the next decade as industrial production in China decreases (Figure 4.17).

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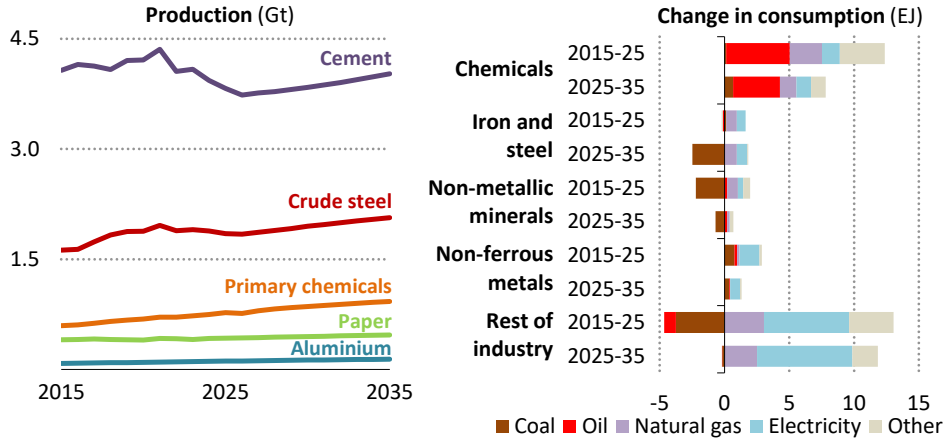
Figure 4.17 ▷ Industrial material production and change in industrial energy consumption by sector and fuel in the STEPS, 2015-2035



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Driven by rising demand in non-energy-intensive sectors, electricity accounts for half of the industrial demand change to 2035; oil's 20% share reflects increasing chemicals production

Notes: Gt = gigatonne. Primary chemicals = ethylene, propylene, aromatics, ammonia and methanol. Electrolytic hydrogen produced on site is reported as electricity. Rest of industry includes non-energy-intensive industries and pulp and paper. Other includes district heat, hydrogen, modern bioenergy, non-renewable waste, solar thermal and geothermal.

Box 4.5 ▷ Impacts of the 2026 energy crisis on industrial natural gas use

The destruction of industrial facilities and the major supply chain disruptions in the Gulf arising from the Middle East conflict could reshape the geography of future industrial production of goods including fertilisers, plastics, aluminium, sulphur and helium.

Industrial natural gas demand in the Middle East and Southeast Asia is likely to be particularly affected. Chemical facilities in the Middle East have been hit hard by attacks, and reconstruction will take time, leaving opportunities for higher production in other parts of the world. This has led to a 16 bcm downward revision to industrial natural gas use in the Middle East in 2035 in *WEO-2026* STEPS compared to *WEO-2025* STEPS (Figure 4.18), while chemicals output has increased in Eurasia, China and North America. This increase is a combination of higher operating rates of existing facilities and, more importantly, investments in new capacities in less uncertain regions, explaining why Middle East industrial output does not fully recover by 2035. Meanwhile, Southeast Asia has experienced project delays, temporary plant shutdowns and the reconsideration of investment plans (Nation Thailand, 2026). Industrial natural gas use has also been revised down in this region compared with the *WEO-2025* STEPS as a result of concerns over the security of supply and price volatility, particularly in non-energy-intensive industries that use coal for longer.

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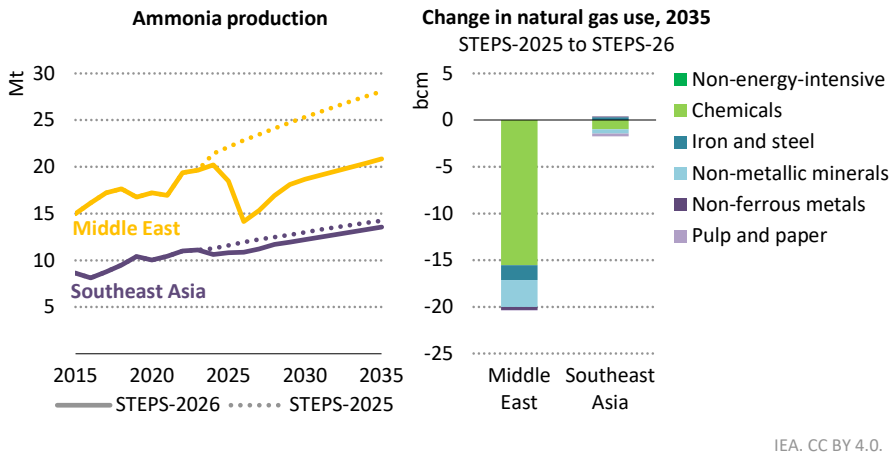
Figure 4.18 ▷ Ammonia production and change in industrial natural gas use by region in the *WEO-2025* and *WEO-2026* STEPS, 2015-2035



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The 2026 energy crisis has reduced industrial natural gas use in the Middle East and Southeast Asia, with damaging consequences for the production of key materials

Note: Mt = million tonnes; bcm = billion cubic metres.

Heat remains the backbone of industrial energy demand

Industrial energy use can be split into five end-use categories: heating, mechanical energy, lighting, cooling and non-energy use (mostly feedstocks). In 2025, almost two-thirds of industrial energy demand was used to supply heat, while 15% was for non-energy use, 12% for motors, 2% for cooling and 1% for lighting (Figure 4.19).

In energy-intensive industries, heat demand mainly comes from the manufacturing of iron and steel (40%), chemicals (26%) and cement (11%). These industries have processes that require high-temperature heat (1 500 °C to reach iron melting point, 1 400 °C for clinker calcination or 850 °C in steam crackers for ethylene production, for example). Today, most of the heat needs in energy-intensive industries are met by coal, natural gas and electricity. In the STEPS, this remains broadly unchanged over the next decade because many facilities are relatively young, have long lifetimes and are designed to use a single fuel.

In non-energy-intensive industries, lower-temperature heat is used in a wide range of industrial processes, such as food and tobacco drying, pulping for paper production or textile dyeing. Just over 70% of demand in these industries is for heat below 200 °C. The fuel mix to supply heat in these sectors is more diverse, with natural gas, electricity and bioenergy serving as the main sources. In the STEPS, electricity and bioenergy grow, respectively, at 4% and 2% per year over the next decade, often at the expense of fossil fuels. This growth is supported by policies in major industrial economies, including China's Action Plan for

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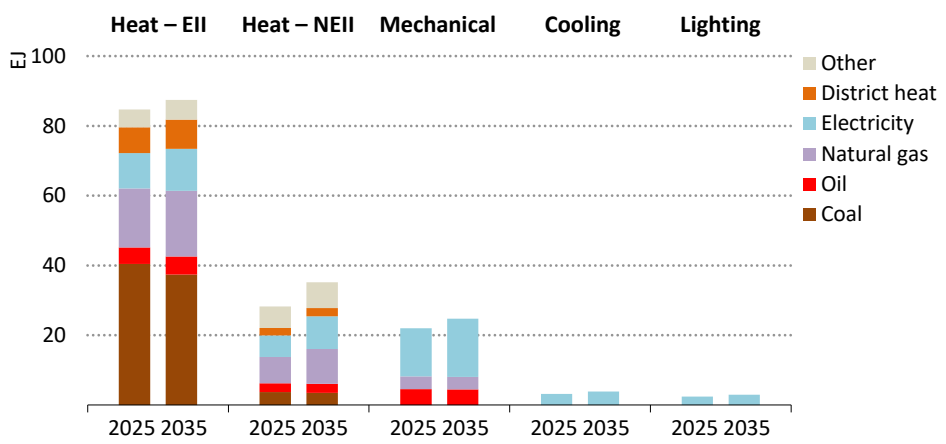
Promoting High-Quality Development of the Heat Pump Industry, the European Union's Innovation Fund Heat Auction, France's Heat Fund, Germany's EEW programme (Bundesförderung für Energie- und Ressourceneffizienz in der Wirtschaft) and the US Department of Energy's Industrial Heat Shot programme.

Figure 4.19 ▷ Global industrial process energy demand by end-use and fuel in the STEPS, 2025 and 2035



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Two-thirds of industrial energy is used to produce heat, mostly from fossil fuels; electricity's share in meeting mechanical demand jumps from 63% to 67% between 2025 and 2035

Notes: Process energy = total energy excluding industrial non-energy use (e.g. petrochemical feedstock); EII = energy-intensive industries; NEII = non-energy-intensive industries. Other includes hydrogen, bioenergy, non-renewable waste, solar thermal and geothermal.

The most notable changes in the next decade occur in mechanical energy supply. Motors have shorter lifetimes than most heavy industrial processes, allowing for faster stock turnover. In non-energy-intensive industries, the combined share of diesel and gas engines in the motor stock falls from 37% in 2025 to 27% in 2035. The higher efficiency of electric motors and MEPS policies together increase the global average efficiency of motors in those industries from 50% in 2025 to 55% in 2035, with best-in-class electric motors (IE3 and above) reaching 60% of electric motor stock. Lighting and cooling needs are entirely met by electricity. Demand for both increases by an average of 2% per year, driven by the growing share of non-energy-intensive industries, but is partly offset by efficiency gains.

Chinese iron and steel sector enters a new phase of restructuring

China's steel sector is entering a period of structural adjustment after more than two decades of exceptional growth (Figure 4.20). Crude steel production rose from around 130 Mt in 2000 to more than 1 000 Mt at its peak in 2020, lifting China's share of global output from around 15% to more than half and making steel a major source of emissions

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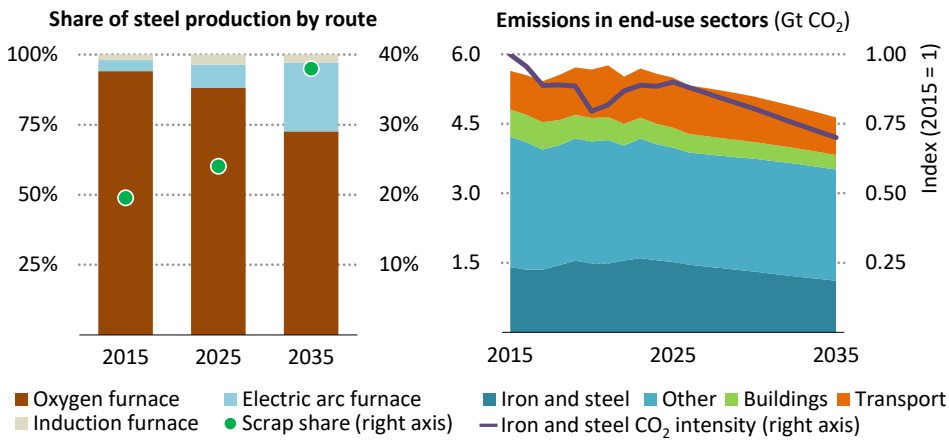
(around 13% of China's total energy sector emissions in 2020). Since 2020, Chinese output has declined by about 2% per year as property and construction activity has slowed. In the STEPS, production falls from 960 Mt today to 910 Mt in 2035, reducing China's share of global production to about 44%.

Figure 4.20 ▷ Share of crude steel production by route, CO_2 emissions by sector and steel emissions intensity in China in the STEPS, 2015-2035



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In China, over the next decade, EAF steel production nearly triples, while iron and steel CO_2 emissions decrease by 400 Mt, and CO_2 intensity declines by 2.5% per year

Notes: EAF = electric arc furnace. Scrap share refers to the proportion of steelmaking inputs supplied by recycled steel scrap rather than primary iron produced from iron ore. Other includes the rest of industry (i.e. excluding iron and steel). Iron and steel CO_2 intensity index is based on iron and steel CO_2 emissions per unit of crude steel production.

Weaker domestic demand, structural oversupply and a less favourable export environment continue to put pressure on steelmakers' margins in China. Exports have helped offset weaker domestic demand, but rising tariffs and trade tensions are making global markets a less dependable outlet for steel producers. At the same time, the European Union's Carbon Border Adjustment Mechanism (CBAM) is underlining the importance of lower-carbon production in major international markets. Domestic policy is reinforcing the move from volume growth towards higher-value output, with China's 15th Five-Year Plan promoting facility upgrades, mergers or exits among less competitive producers, together with greater output of high-value electrical and rolled steel.

Growing scrap availability in China provides an important opportunity to accelerate low-carbon electric steel production, reduce primary iron demand, allow steelmaking to benefit from increasingly available low-cost variable renewable electricity, and contribute to reducing CO_2 emissions in line with China's stated goals of seeing emissions peak by 2030

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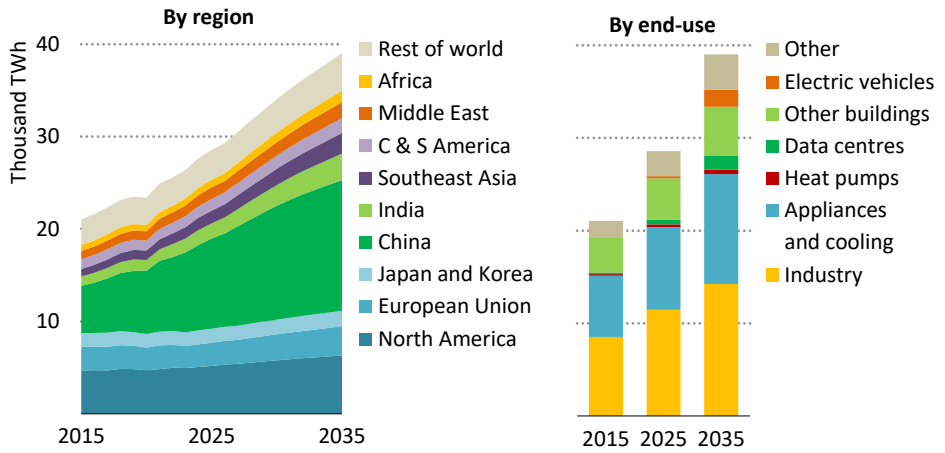
and reaching net zero by 2060. In China, electric arc furnace (EAF) steel facilities currently operate at about 50% utilisation, leaving scope to raise their production without major capacity additions (CREA, 2025). In the STEPS, overall steel output declines slightly over the next decade, while EAF production nearly triples and scrap use increases by nearly 50%. The expansion of EAF production, lower coal-based steel output, efficiency improvements and increased scrap use together reduce steel-related emissions by around 400 Mt CO_2 by 2035 in China, which is more than South Africa's total energy-related CO_2 emissions today. This translates into a 2.5% annual reduction of the sector's emissions intensity by 2035.

4.4 Electricity

4.4.1 Demand

Demand for electricity grew at well over twice the rate of energy demand in 2025, reaffirming that the world has entered the Age of Electricity. Demand growth of 3.2% in 2025 was in line with the average over the last decade, but it was slower than the 4.9% surge in 2024, which was largely due to one-off factors such as higher cooling demand in India and Southeast Asia. In the STEPS, electricity demand grows by 3.2% per year to 2035, four times faster than total energy demand (which rises by 0.8% per year) and faster than global GDP (which grows by 3.0% per year). By 2035, electricity demand increases by 10 500 TWh – as large as the entire electricity demand among advanced economies today (Figure 4.21).

Figure 4.21 ▷ Global electricity demand by region and end-use in the STEPS, 2015-2035



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All regions see demand growth by 2035, with cooling and appliances contributing 30% of the total – the largest end-use increase

Note: Other includes agriculture, non-road transport and other energy sector.

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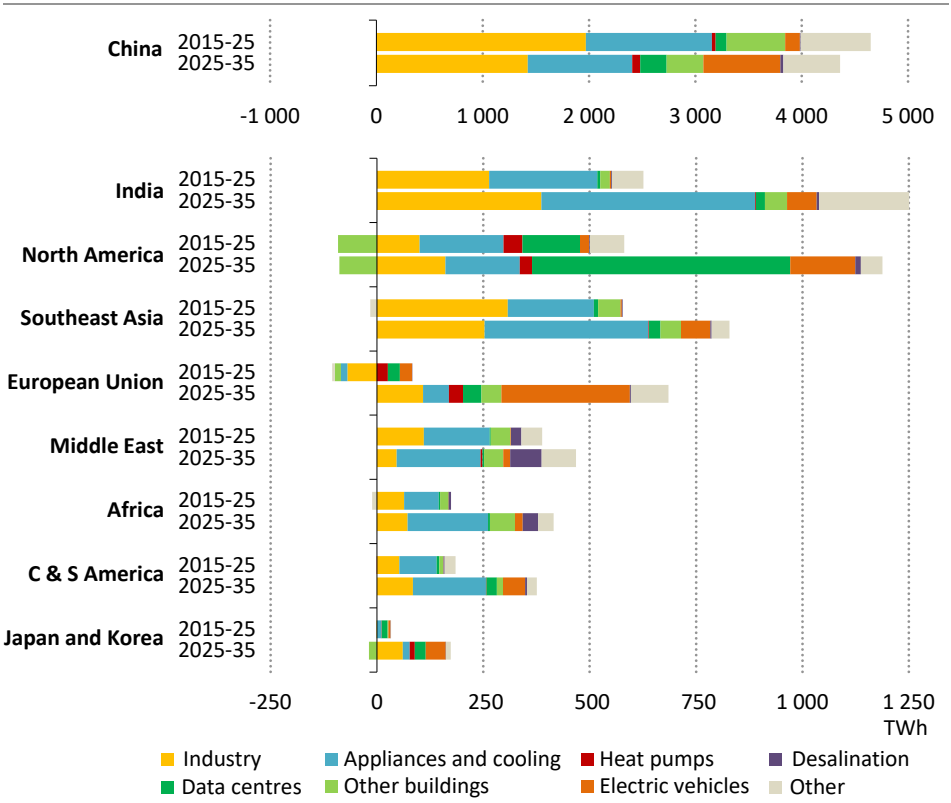
The Age of Electricity involves new patterns of regional demand growth. Over the last decade, China alone was responsible for more than 60% of electricity demand growth, while advanced economies contributed less than 10%. In the STEPS, the next decade sees a rebound of electricity demand in advanced economies, which contribute almost 25% to global growth, while China's share of global growth falls to around 40%. In emerging market and developing economies outside China, electricity demand growth accelerates: demand increases each year on average by 6% in India, 5% in Southeast Asia, by more than 4% in Africa and 3% in the Middle East and in Central and South America, reflecting a mix of rising incomes, improved access to electricity, increasing cooling demand and higher levels of appliance ownership (Figure 4.22). India and Southeast Asia together add 2 100 TWh of demand by 2035.

Figure 4.22 ▷ Change in electricity demand by region and end-use in the STEPS, 2015-2035



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Electricity demand grows in all regions, led by cooling, electric vehicles and data centres; regional patterns of demand vary

Note: Other includes agriculture, non-road transport and other energy sector.

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The next decade is also shaped by the development of new uses of electricity. Conventional uses have dominated demand growth since 2015, with industry contributing 40% of total additional demand. However, going forwards, EVs, low-emissions technology manufacturing, data centres and artificial intelligence (AI), heat pumps and electric desalination all increase their demand for electricity significantly. Some of these loads offer valuable flexibility resources; there is scope to combine equipment control with appropriate tariffs, interoperability standards and market access to tap their flexibility potential.

Data centres are growing in number, driven by digitalisation and investment in AI, but their location and the associated increases in demand remain highly concentrated: in the STEPS, demand increases from about 500 TWh today to 1 500 TWh by 2035, with more than 80% of this demand coming from China, the European Union and the United States (Box 4.6). In the United States, data centres alone account for just above half of electricity demand growth to 2030, and they are responsible for just above 10% of overall demand by then.

Other electricity demand growth in the STEPS comes from a variety of sources. EVs consume 1 840 TWh in 2035, eight times more than today. Almost two-thirds of this growth originates in China and the European Union, but emerging EV markets such as Southeast Asia contribute around 70 TWh of the total. The manufacturing of low-emissions technologies such as batteries and solar panels adds a further 1 200 TWh of demand by 2035, most of it in China. Heat pumps play a key role in electrifying space and water heating, especially where needs are significant. In the STEPS, they account for more than 15% of the heating equipment stock by 2035, up from about 10% today, but given their high efficiency, their contribution to demand growth is just 200 TWh. In the Middle East and North Africa, water desalination electrifies rapidly as reverse osmosis becomes the preferred treatment process; while desalination accounts for 2% of global demand growth, its share in the region is almost 20%.

Cooling and appliances are the largest drivers of electricity demand growth globally, propelled by higher incomes and rising temperatures. In the STEPS, their consumption increases by 2 900 TWh by 2035, which is more than the entire demand of the European Union today. Cooling and appliances account for almost 30% of global demand growth over the next decade, of which almost 90% occurs in emerging market and developing economies. Cooling demand has profound implications for power systems, as AC operation is highly seasonal. While cooling accounts for only 12% of electricity demand by 2035, it contributes 30% of peak electricity demand (see Chapter 7).

Electricity accounts for 23% of total final energy consumption, but it is the key energy source in sectors that account for over 45% of the global economy. In the STEPS, electrification rates increase in all regions driven by fuel switching to electricity alongside growing demand for cooling, appliances and data centres (Figure 4.23). China, whose economy is already highly electrified, sees its electrification rate rise from 32% today to 43% by 2035, the highest of any major economy. Japan and Korea follow a similar trend and reach an electrification rate of 39%. The European Union sees its rate rise to above 30% by 2035, up from 24% today. Electrification rates in India and Southeast Asia grow rapidly, reaching levels similar to those in advanced economies. Africa and the Middle East are the only regions where electrification

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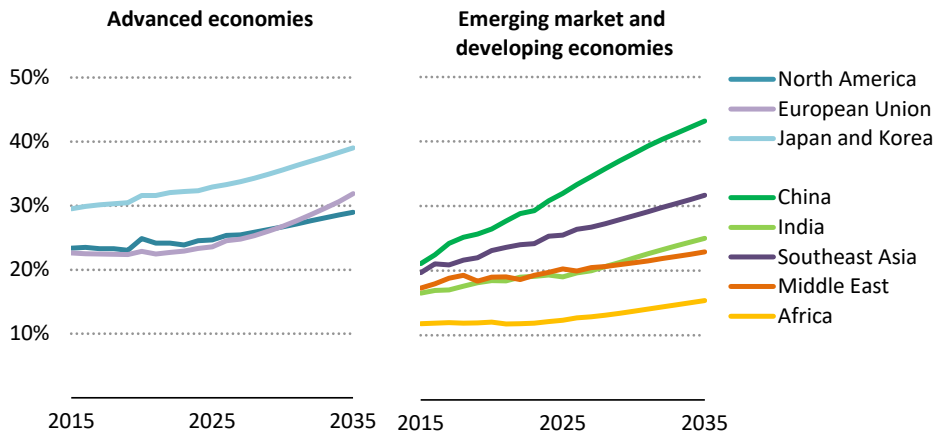
rates remain below 23% by 2035, due to significant reliance on traditional use of biomass in the former and substantial fossil fuel resources in the latter.

Figure 4.23 ▷ Share of electricity in total final energy consumption by region in the STEPS, 2015-2035



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Electrification rates in the European Union and North America increase to 2035 after a decade of sluggish growth; Japan, Korea and most EMDE continue on a rising trend

Box 4.6 ▷ Is AI a game changer for the energy sector?

AI is emerging as one of the most consequential technology developments of recent decades. It has the potential to become a general-purpose technology, with significant implications across sectors. Given this, the IEA has deepened its analysis and data collection, publishing numerous landmark reports on the topic (IEA, 2025 and 2026c).

The electricity consumption of the data centres that train and run AI models is increasing rapidly; in 2025, it rose by around 15%. However, consumption by data centres remains small, accounting for about 1.7% of total electricity demand globally. Yet because data centres cluster together, they represent much larger shares of consumption in several local markets. Together with the increasing size, development speed, specific load profile and technological complexity of AI data centres, this is putting pressure on technology supply chains and local grids. The IEA projects that overall data centre electricity consumption doubles by 2030 in the STEPS, but that of AI-focused data centres grows much faster. While there continue to be substantial energy efficiency improvements in infrastructure, hardware and software, they are expected to reduce rather than cancel out projected demand growth from AI and information technology services.

After 2030, the outlook becomes much more uncertain: the uptake of AI and the level of efficiency improvements of the technology itself will determine the demand trajectory.

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At the same time, AI deployment is associated with risks that need to be overcome, including those relating to cybersecurity, data governance, communications resilience and requirements for human oversight. The expansion of AI data centres has also raised concerns about electricity tariffs in some regions, and there is rising local opposition to some projects.

AI has the potential to optimise operations in the energy sector by adding a layer of more efficient data processing and decision-making support on top of existing processes, although some are quite optimised already. The largest gains are likely to come from shifts in underlying technologies. For example, an AI-enabled smart thermostat may result in energy savings, but not as much as switching from a gas boiler to a heat pump. From this perspective, the largest – but also most uncertain – implications of AI for the energy sector could come from its potential to accelerate innovation in energy technologies in the longer term. Other barriers to the uptake of AI in the energy sector include skills gaps in the energy workforce, regulatory regimes that rightly prioritise security over fast process innovation, and gaps in the digitalisation of energy equipment.

Economists, businesses and policymakers have raised the possibility that AI may accelerate economic growth. If it does, this could increase energy demand. However, the productivity gains of AI are currently focused in sectors that are not energy intensive, such as services. For this reason, if there is a near-term boost to growth from AI, it appears unlikely to result in a proportional increase in energy demand.

Overall, the picture that emerges from IEA analysis is largely one of continuity at the macro level for the energy sector in the near term. But the data centre build-out has substantial local implications for the most affected electricity markets, sectors and technologies, and the longer-term range of possible outcomes across energy demand and energy technologies is large.

4.4.2 Electricity generation

The global electricity generation mix changes rapidly in the STEPS as today's policy settings, technology cost trends and market dynamics continue to reshape the power sector. Fossil fuels represent close to 60% of total generation today, but their share declines steadily to 2035 as low-emissions supply expands. Coal remains the largest source of electricity beyond 2030 but is overtaken by solar photovoltaics (PV) by 2035 (Figure 4.24). Renewables remain a primary focus of power sector policy; by 2025, 124 countries had established renewable electricity policies (REN21, 2026). Solar PV generation increases three-and-a-half-fold between 2025 and 2035, supported by low costs, short project lead times and broad policy support. Wind generation is two-and-a-half times higher. The curtailment of solar PV and wind is projected to increase in all regions (see Annex A).

Renewables are the main source of additional generation in the STEPS, with their share in the global electricity mix rising from 33% in 2025 to half by 2035, led by solar PV and wind. Solar PV delivers just over 20% of generation by 2035, and wind close to 15%, about one-fifth

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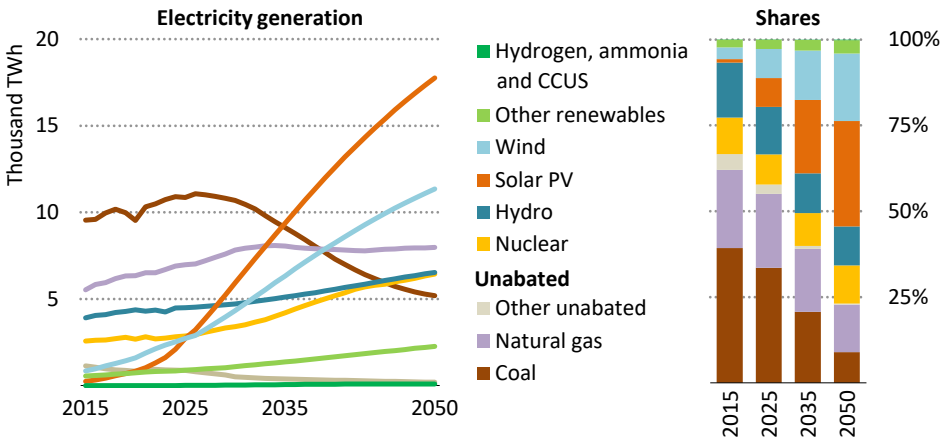
of which is offshore wind. Nuclear power is experiencing a comeback, with nearly 90 GW of new capacity under construction in 17 countries and recent decisions to extend the lifetimes of some existing reactors. As growth for nuclear outpaces total demand growth, its share of electricity generation edges up from 9% in 2025 to 10% in 2035. Natural gas remains the second-largest source of electricity generation today, rising by around 15% to 2035 before plateauing, with its share declining slightly. Coal follows a different path: its share has already fallen and drops to just above 20% by 2035 for the first time in modern energy history, even as coal plants continue to provide large volumes in systems with sizeable existing fleets. Recent energy security concerns are providing some near-term support to coal use and slowing plant retirements in several markets. However, these developments do not reverse the longer-term decline in global coal-fired generation (see Box 1.2 in Chapter 1). These shifts deepen to 2050 as coal-fired generation falls below a 10% share of generation globally, natural gas declines to a share of less than 15%, nuclear edges up again to 11%, and the share of renewables rises to two-thirds.

Figure 4.24 ▷ Global electricity generation by source in the STEPS, 2015-2050



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Power systems are being reshaped by the rise of renewables and nuclear expansion, steadily reducing the share of coal; natural gas remains an important contributor

Notes: CCUS = carbon capture, utilisation and storage; PV = photovoltaics. Other renewables include bioenergy and renewable waste, concentrating solar power, geothermal and marine. Other unabated includes oil and non-renewable waste.

Every major region sees its power mix evolve over the next decade in the STEPS, but the balance between renewables, nuclear, gas and coal depends strongly on local resources, policies and existing infrastructure (Figure 4.25). In emerging market and developing economies, close to half of additional generation over the past decade came from fossil fuels, but that changes over the coming decade, as most new generation to 2035 is supplied by low-emissions sources.

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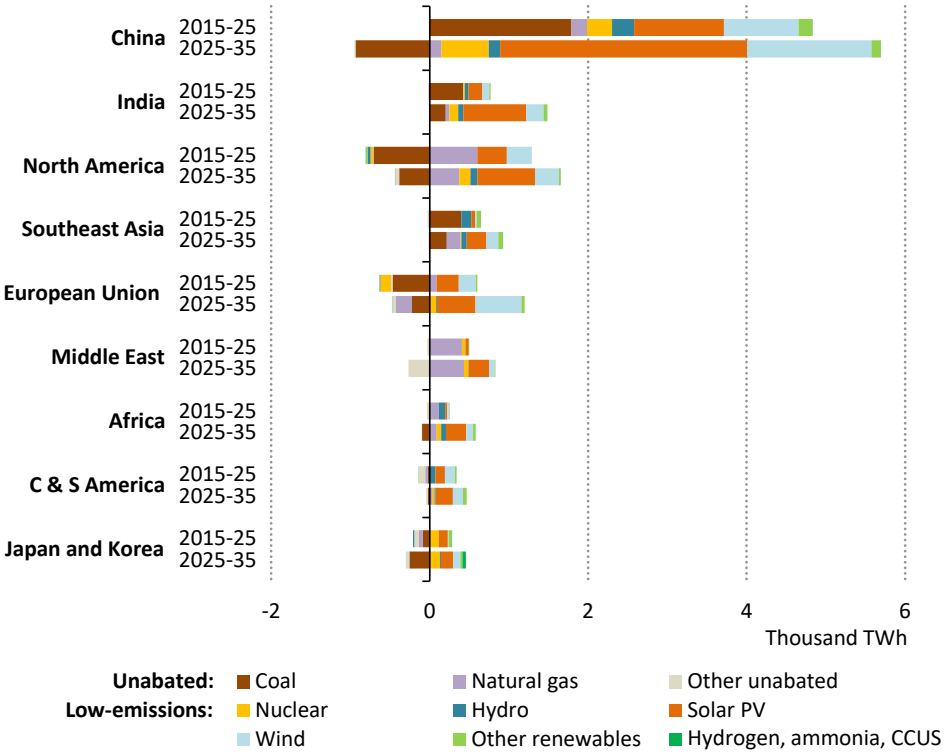
Figure 4.25 ▷ Change in electricity generation by region in the STEPS, 2015-2035



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Each region meets new electricity demand with a unique mix of sources to 2035, as wind and solar PV play larger roles than in the past and gas continues to grow in some regions

Notes: Other renewables include bioenergy and renewable waste, concentrating solar power, geothermal and marine. Other unabated includes oil and non-renewable waste.

China, guided by its 15th Five-Year Plan, is central to the global outlook because of the scale of its electricity system and the speed of change in its generation mix. Growth in solar PV and wind generation together exceeds total demand growth to 2035, while the increase for nuclear generation is larger than in the previous decade. This means coal plants increasingly pivot towards supplying flexibility rather than bulk electricity, and coal-fired generation falls sharply, even as installed coal capacity continues to grow. This reverses the trend of the past decade, when coal still provided a large share of incremental supply (see Chapter 8).

India and Southeast Asia follow more mixed pathways. In India, solar PV becomes the main source of additional generation over the next decade, and coal-fired output accounts for a smaller share of the additional power needed to meet strongly rising electricity demand than in the previous decade. This shift is supported by measures in the draft National Electricity

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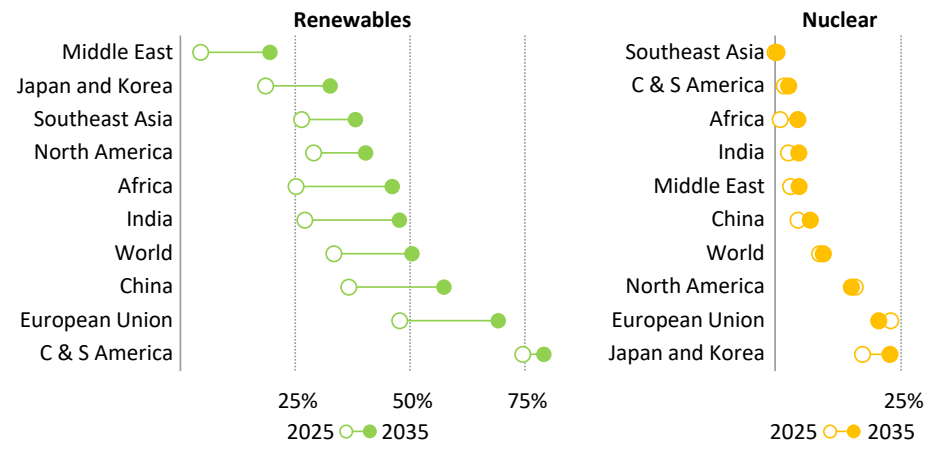
Plan to facilitate renewables integration and repurpose older fossil fuel plants. In Southeast Asia, fossil fuels continue to meet a larger share of additional generation than in many other regions; both coal- and gas-fired generation expand, although solar PV and wind each make a much larger contribution than in the past. Government policies play an important part in shaping outcomes. For example, Indonesia's Electricity Supply Business Plan 2025-2034 targets 42.6 GW of new renewable capacity.

In Africa and in Central and South America, low-emissions sources provide most of the increase in generation to 2035. Central and South American countries build on power systems in which low-emissions sources are already playing a major role, with hydropower remaining the backbone of supply and most new growth coming from solar PV and wind. In Africa, solar PV generation increases the most of any source, complemented by growth for hydropower and wind, as well as coal and natural gas.

Advanced economies see renewed growth in generation, with most of the increase met by renewables and nuclear. The composition varies considerably: solar PV leads growth in North America and wind in the European Union, while nuclear restarts and higher output play a larger role in Japan and Korea. Coal-fired generation declines, while gas-fired output remains broadly flat to 2035. These trends are aligned with major policy frameworks, including National Energy and Climate Plans across the European Union, the 7th Strategic Energy Plan in Japan, and the 11th Basic Plan on Electricity Supply and Demand in Korea.

Figure 4.26 ▷ Share of renewable sources and nuclear in electricity generation by region in the STEPS, 2025 and 2035



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The share of low-emissions sources of electricity – including renewables and nuclear – is on the rise, with most regions above 50% by 2035 and leading regions passing 75%

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Renewables and nuclear play different roles in this evolving mix. Renewables increase their share of generation in every region to 2035, supported by improving technology economics, although the scale and composition of growth vary with resources and market conditions (Figure 4.26). The competitiveness of solar PV, wind and battery storage has improved dramatically in recent years and is projected to further improve (Box 4.7). Nuclear starts from a much more uneven position, providing nearly one-quarter of generation in some regions (though higher in some individual countries) and none in others. Its contribution increases in most regions to 2035, including as newcomer countries in Africa and Southeast Asia develop their first projects, while ageing fleets and insufficient replacement capacity lead to a smaller role in some established markets.

Box 4.7 ▻ Competitiveness of solar PV, wind and battery storage

The cost of key low-emissions power technologies has fallen dramatically since 2010; innovation, manufacturing scale and performance gains have reduced the levelised cost of electricity (LCOE) by around 90% for solar PV and 70% for wind, and the upfront cost of batteries by around 90%. These cost reductions mean that solar PV and onshore wind power have lower average generation costs today than new coal, gas and nuclear power plants in most markets. Costs are projected to continue falling in the STEPS, with declines of around 35% for solar PV, 30% for batteries and 10% for onshore wind between 2025 and 2035.

However, competitiveness is not determined by generation costs alone. While LCOE captures investment, operating, fuel and CO_2 costs (where emissions are priced), it does not account for the timing of electricity production, contributions to adequacy and reliability, or flexibility services. To reflect these factors, the IEA uses the value-adjusted levelised cost of electricity (VALCOE), which incorporates system value alongside costs. Although VALCOE does not allocate grid expansion costs to individual technologies or include emissions that are not priced in markets, it provides a better measure of competitiveness than LCOE and can be compared with average system generation costs as an indicator of affordability. Overall integration costs are included in the assessment of total system costs (see Chapter 7).

The rapid deployment of solar PV and wind has been underpinned by their improving economics, but their competitiveness also depends on their value to power systems. As renewable penetration rises, weather variability and lower market value at high renewable output (known as the cannibalisation effect) become increasingly important determinants of value. In a growing number of markets, periods of high renewable output coincide with lower or even negative wholesale prices, reducing revenues for standalone projects (IEA, 2026d). Against this backdrop, solar PV coupled with battery storage becomes more attractive. By 2035, the additional system value provided by batteries is projected to outweigh the added storage costs they entail in major markets, making solar PV plus storage more competitive than standalone solar PV (Figure 4.27).

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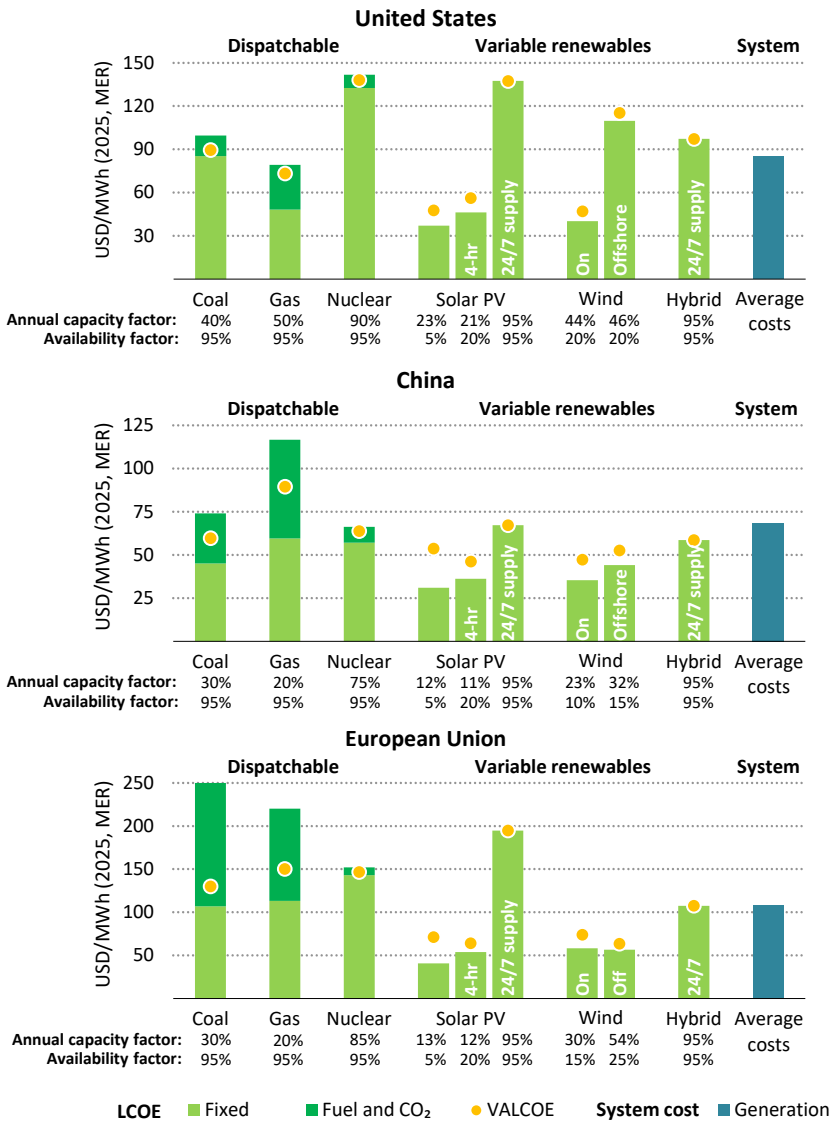
Figure 4.27 ▷ **LCOE and VALCOE of power technologies in selected regions in the STEPS, 2035**



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Solar PV and wind are competitive with dispatchable sources in major markets in 2035

Notes: MWh = megawatt-hour; MER = market exchange rate. LCOE = levelised cost of electricity; VALCOE = value-adjusted levelised cost of electricity. 4-hr refers to battery storage duration. 24/7 refers to the ability to provide power in all hours of the day and all week. For wind, On = onshore; Off = offshore. Hybrid refers to an optimised combination of wind, solar PV and battery storage. Annual capacity factor describes the average output over the year relative to the maximum rated capacity. Availability factor is the share of nameplate capacity that can be reliably expected to generate electricity during times of peak demand.

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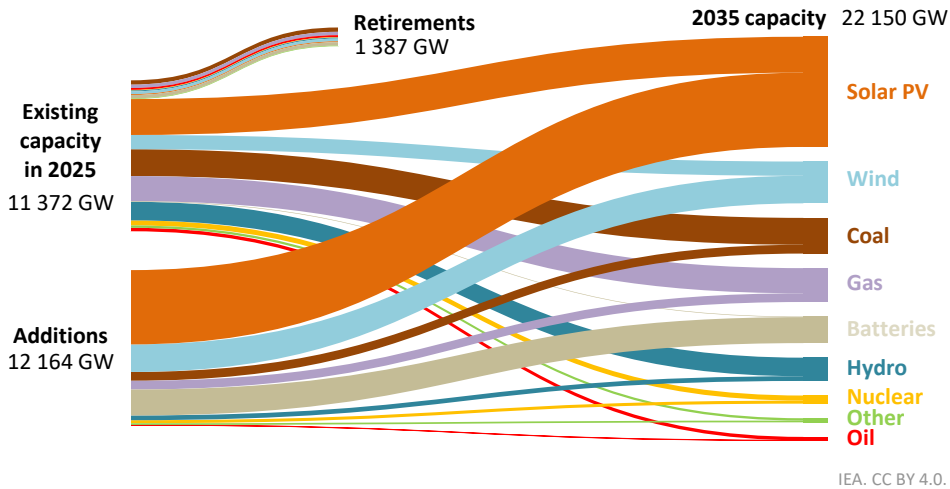
Combining solar PV, wind and battery storage in hybrid projects can provide high levels of reliability, reaching average capacity factors close to 95% and delivering electricity on a near-continuous 24/7 basis. However, achieving this outcome requires a substantial oversizing of renewable capacity and storage to manage weather-related variability. For example, even without wind, providing 100 megawatts (MW) of firm capacity could require around 600 MW of solar PV together with 400 MW/1 600 megawatt-hours (MWh) of battery storage. In 2035, even with large volumes of surplus generation, hybrid projects of solar PV and battery storage could achieve a VALCOE of around USD 70/MWh in China, USD 140/MWh in the United States and USD 195/MWh in the European Union. Adding onshore wind further improves performance and could reduce costs by 15-45%, bringing hybrid projects into direct competition with coal- or gas-fired generation and putting them close to average system generation costs in 2035. As costs continue to fall, these projects become an increasingly attractive option for grids and major electricity consumers, including industrial facilities and data centres seeking reliable, round-the-clock power (IEA, 2025).

Figure 4.28 ▷ Global power generation installed capacity, additions and retirements in the STEPS, 2025-2035



Variable sources surge to 2035, while dispatchable capacity from batteries, coal, natural gas, hydro and nuclear continues to grow

Notes: GW = gigawatt. Other includes bioenergy, geothermal, concentrating solar, and marine power.

The world's installed power capacity mix is reshaped in the STEPS, which sees a growing split between variable and dispatchable sources. Solar PV and wind account for most capacity additions to 2035; as a result, variable renewables account for the clear majority of installed capacity by 2035 (Figure 4.28). Their contribution to generation is less than their share of

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installed capacity, since they have lower average capacity factors than many dispatchable technologies. Even so, variable renewables become the leading source of generation. Their expansion changes how power systems operate, increasing the need for flexibility, stronger grids and storage to manage daily and seasonal variability, reduce curtailment and maintain reliability (see Chapter 7).

Dispatchable capacity remains central to electricity security, and in the STEPS, it expands alongside variable renewables. Battery storage becomes one of the fastest-growing power technologies, and by 2035, its contribution to capacity puts it in the same league as coal, natural gas and hydropower. Batteries do not provide bulk generation, but they help shift output across the day, support peak demand, provide ancillary services and improve the value of solar PV and wind. Hydropower, bioenergy, geothermal and other renewables provide firm or flexible low-emissions electricity in many systems. Natural gas capacity expands to 2035 in many markets where domestic resources are available or flexibility is highly valued. Nuclear capacity enters a period of renewed growth, supported by new construction, lifetime extensions and restarts, while coal- and oil-fired additions remain limited and retirements increasingly outweigh new capacity.

4.4.3 Grids

Electricity grids underpin secure and affordable power systems, providing the flexibility, reliability and resilience needed as electricity systems evolve. As electricity demand and energy transitions accelerate in the STEPS, grids expand and modernise to transmit higher volumes of electricity, integrate new solar PV and wind capacity, and provide electricity access to new demand centres.

Today's global electricity networks stretch more than 85 million kilometres (km), having expanded by around 30% over the past decade. More than 90% of this expansion consisted of additions to lower-voltage distribution networks, which carry electricity over the final kilometre to end users. The remainder were new higher-voltage transmission lines, which require longer project lead times. In regions such as sub-Saharan Africa, some of these new lines delivered electricity to communities for the first time, expanding electricity access. Although they account for a much smaller share of the total, transmission networks play a key role in ensuring electricity reaches all demand centres – some of which are located far from generation plants – as well as in interconnecting regions and ensuring grid resilience when there are outages.

From 2015 to 2025, close to 18 million km of new lines were added in emerging market and developing economies, where electricity demand has grown the fastest. China and India together accounted for over 60% of these new lines, and Africa, Central and South America, and Southeast Asia for much of the rest. Two million km were added in advanced economies, with the largest increases in Europe, the United States and Australia. In Europe, where electricity demand has remained relatively stable over the past decade, grid expansion was driven in part by the need to connect new variable renewable capacity, which is often located far from existing lines.

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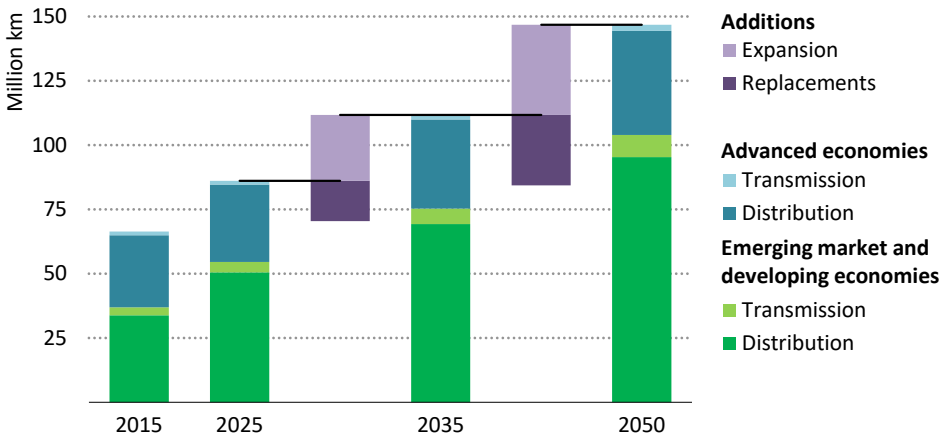
In the STEPS, global grids expand by 26 million km – a 30% increase – to 2035 and by a further 35 million km to 2050 (Figure 4.29). The majority of this expansion takes place in emerging market and developing economies, where the most rapid electricity demand growth occurs. These economies add 21 million km of lines by 2035, 25% of which are in China, and nearly 30 million km more by 2050. In advanced economies, 5 million km of new lines are added by 2035, nearly one-third of which are in the United States, and over 6 million km more by 2050.

Figure 4.29 ▷ Electricity grids by type, driver and region in the STEPS, 2015-2050



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Global grids approach 150 million km by 2050, with expansion driven by higher demand and renewables; over 100 million km of lines are added or modernised over the period

Note: km = kilometre.

Over 90% of these new lines are constructed to meet rising electricity demand, but grid expansion is also driven by the increasing deployment of variable renewables such as solar PV and wind. Unlike many traditional power plants, which can be built closer to where end users are, renewables are located where the best resources are available, requiring that grids be built out to them. For offshore wind, this involves the installation of subsea cables to connect offshore generation to the grid. When variable renewables account for a large share of overall generation, additional grid reinforcement is also needed to ensure system reliability. In the STEPS, grid expansions to integrate variable renewables account for over 2 million km of the global total by 2050, mostly in advanced economies and China.

Around 16 million km of existing lines are also replaced or refurbished in the STEPS by 2035, and about 45 million km by 2050, as they reach the end of their typical lifetime of around 40 years. China, the European Union and the United States together account for half of these, the vast majority of which are lower-voltage distribution lines. In advanced economies, where future grid expansion is limited and existing grids are ageing, replacements account for over 60% of total additions to 2050. In emerging market and developing economies, where grids are typically newer and expanding rapidly, replacements account for only one-third of the total. The replacement and refurbishment of lines is a well-established

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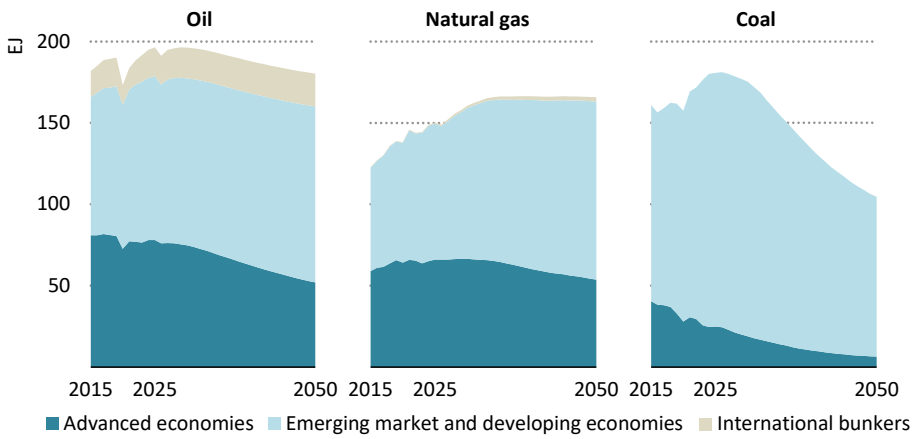
process that typically takes much less time than the installation of new lines. However, project needs vary by country, and underground cables require more extensive work than overhead lines.

4.5 Fuels

The 2026 energy crisis is one of many factors affecting this year's long-term outlook for fuels. In aggregate, oil, gas and coal demand in the STEPS declines by 3% to 2035 and 15% to 2050 (Figure 4.30). The share of fossil fuels in total energy demand falls from 79% today to 60% in 2050; the share in TFC declines from 65% to 54% over the same period. Compared with the *WEO-2025* STEPS, downward revisions to oil and gas demand in 2035 stem from the Asia Pacific and the Middle East, more than offset by upward revisions elsewhere, mainly in North America and Europe.

Figure 4.30 ▷ Fossil fuel demand by fuel in the STEPS, 2015-2050



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Natural gas demand in 2035 is around 10% higher than today, oil demand is similar, and coal demand is 14% lower; after 2035, coal and oil decline while gas demand plateaus

From 102 mb/d in 2025, oil demand dips and then recovers from the crisis but only to a maximum of around 103 mb/d, before entering a long period of gradual structural decline, mainly caused by reductions in oil use in road transport, along with buildings and power. Weaker demand means equilibrium prices remain around USD 70-75 per barrel out to 2050, limiting production increases from higher-cost producers. Consequently, a growing share of supply comes from the Middle East, where resources are large and decline rates are relatively low. Oil remains the largest single energy source to 2050 in the STEPS.

Natural gas demand grows from 4 300 bcm in 2025 to 4 800 bcm in the mid-2030s and remains around this level to 2050. Despite ample LNG availability in the early years of the outlook, long-term growth in natural gas demand remains limited. By 2035, declining

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demand in most advanced economies is more than offset by increased consumption for power and industry in emerging market and developing economies, with notable growth in the industrial sector in China and the power sector in the Middle East and in Southeast Asia.

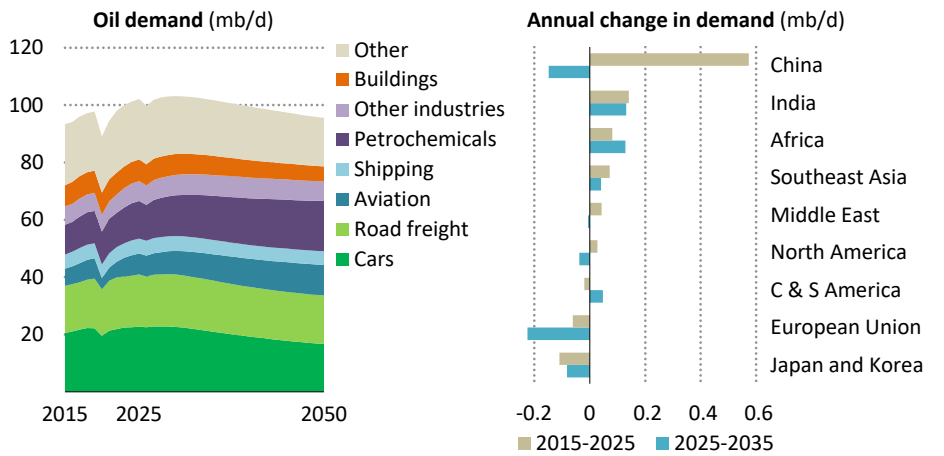
Coal sees the largest decline, with demand falling by 14% to 2035 and 42% to 2050. Nearly all this drop comes from advanced economies and from China, where coal-fired capacity additions continue but coal shifts from baseload generation towards providing flexibility and reserve capacity. In India and Southeast Asia, the two main coal-consuming regions where coal demand rises to 2035, growth is underpinned by both steam and metallurgical coal use.

4.5.1 Oil

Demand

Global oil demand stands at 102 mb/d in 2035, similar to levels in 2025, and then gradually declines to 96 mb/d in 2050, 6% lower than in 2025 (Figure 4.31). Road transport demand for oil falls by 5% by 2035 as EV sales grow strongly, while aviation and petrochemical feedstock demand grows by 25% and 17%, respectively.

Figure 4.31 ▷ Global oil demand and average annual changes in the STEPS, 2015-2050



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Oil demand starts to decline as the reversal of China's demand trend and continued reductions in demand in advanced economies outweigh growth elsewhere

Notes: Other industries = industry sector excluding petrochemicals. Other includes other non-energy use, other energy sectors, power, agriculture and other transport. Excludes biofuels.

China sees oil demand fall from 17 mb/d in 2025 to 15.5 mb/d in 2035. The share of road transport in total oil demand in China declines from 34% today – already the lowest among major economies – to 20% in 2035 as the rapid electrification of its vehicle fleet continues.

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Road fuel demand displaced by EVs grows fivefold over the same period to 5.5 mb/d, more than offsetting the 1.2 mb/d growth in oil use as a petrochemical feedstock.

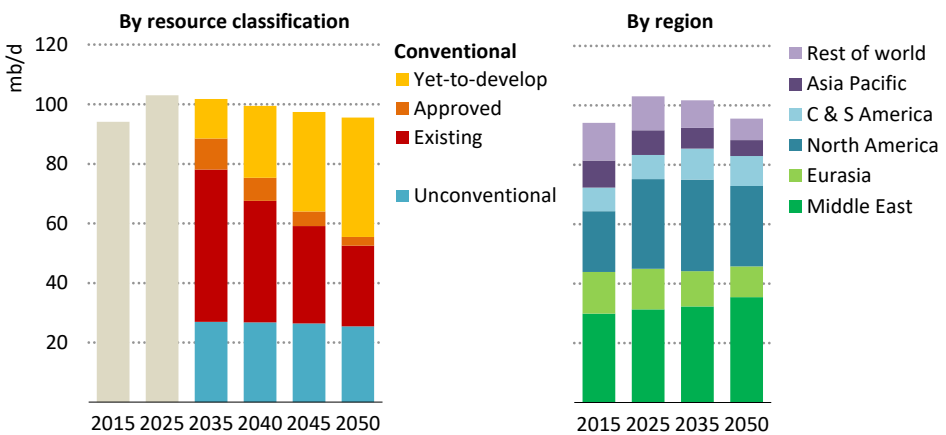
India leads oil demand growth in the STEPS, adding 1.3 mb/d to 2035, which is around half of the total increase in emerging market and developing economies. Africa also sees strong growth of close to 1.3 mb/d to 2035 as ICE cars and medium and heavy freight truck sales increase. Southeast Asia's oil demand grows more slowly than during the previous decade but continues to increase to 2035, driven in part by a 60% growth of aviation revenue passenger kilometres. In the Middle East, oil use in the power sector falls by 1.3 mb/d to 2035, more than offsetting growth in petrochemical feedstock and in road transport.

Oil demand in advanced economies falls from 41 mb/d in 2025 to 37 mb/d in 2035, continuing the decline already visible over the past decade. The largest decline is seen in the European Union; demand remains broadly flat in the United States.

Supply

In the STEPS, oil supply rises to a maximum of 106 mb/d before falling marginally below its 2025 level by 2035. Non-OPEC+ production peaks in the early 2030s, while the OPEC+ share of global supply falls from 46% in 2025 to 42% in 2035 before recovering to 46% again in 2050.

Figure 4.32 ▷ Oil supply by resource classification and region in the STEPS, 2015-2050



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Even with continuing investment in existing sources of supply, meeting demand in the STEPS requires a growing contribution from new fields, much of which comes from the Middle East

Notes: Existing projects include primary, secondary and enhanced oil recovery techniques and include extensions, such as infrastructure-led expansions. Approved projects are those that have reached a final investment decision as of 2026 and are scheduled to start production from 2026 onwards. Yet-to-develop supply includes discovered and undiscovered resources that are yet to be approved for development. See Annex C for definitions of unconventional oil.

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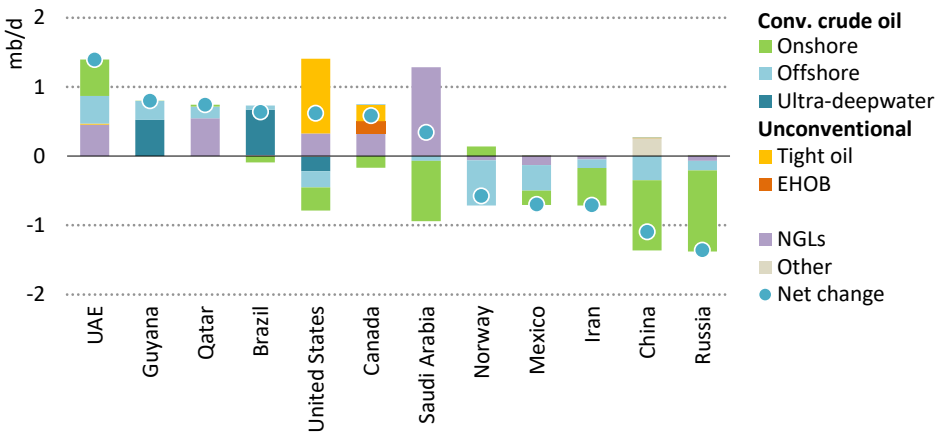
With continued investment, supply in 2035 from conventional projects existing today totals around 50 mb/d, while unconventional oil, including tight oil, and extra-heavy oil and bitumen, contributes around 27 mb/d (Figure 4.32). Projects that have been approved and are under development contribute over 10 mb/d to supply in 2035. Although demand in 2035 is similar to the level in 2025, meeting it requires around 13 mb/d of supply from new projects that had not been approved for development as of 2026.

The Middle East remains the world's largest producing region, and its total oil production increases by about 1 mb/d between 2025 and 2035 (Figure 4.33). It plays a particularly important role in meeting demand after 2035 as output declines elsewhere in the world, and its oil production increases by a further 3 mb/d between 2035 and 2050. Oil production in Saudi Arabia remains around 12 mb/d through to 2035, with the share of natural gas liquids (NGLs) rising to about 30% of total output in 2035 as the Jafurah unconventional gas field is developed. Supply from Iraq is broadly steady over the next ten years and then increases by over 1.2 mb/d between 2035 and 2050, supported by new export routes. Following its withdrawal from OPEC in 2026, the United Arab Emirates sees production grow from 4.4 mb/d in 2025 to 5.8 mb/d in 2035. Iran produced 4.7 mb/d of oil in 2025, and production falls marginally to 2035 in the STEPS, although the outlook is highly uncertain.

Figure 4.33 ▷ Change in oil supply in selected producing countries in the STEPS, 2025-2035



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Natural gas liquids from the Middle East and North America provide most of the supply upside to 2035, partly offsetting declines from mature conventional crude producers

Notes: UAE = United Arab Emirates; Conv = conventional; EHOB = extra-heavy oil and bitumen; NGLs = natural gas liquids. Ultra-deepwater includes production at a water depth greater than 1 500 metres. Other includes coal-to-liquids (CTL), gas-to-liquids (GTL), enhanced oil recovery (EOR), Arctic oil, kerogen oil and additives.

North America is the world's second-largest producing region, and output increases by close to 1 mb/d to 2035. Total oil supply in the United States rises from 22 mb/d in 2025 by a

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further 2 mb/d to the early 2030s before starting to decline. Canadian production rises from 6.4 mb/d in 2025 to 7 mb/d in 2035, supported by increases in tight oil production and export capacity. Supply from Mexico falls from 1.8 mb/d in 2025 to 1.2 mb/d in 2035, reflecting a maturing resource base and limited new project additions.

Central and South America sees 2.3 mb/d of production growth to 2035. The largest increases come from Guyana (35% of the total regional increase), where development continues in its prolific Stabroek block; Brazil (30% of the total), with further pre-salt projects coming online; and Argentina (20% of the total), led by continued tight oil development of its Vaca Muerta formation. Venezuela's heavy oil sector has seen renewed interest from international operators, and production increases from 1 mb/d in 2025 to 1.5 mb/d in 2035, which entails around USD 70 billion of cumulative new upstream investment. A return to pre-2015 levels of 2.7 mb/d would require USD 120 billion of investment cumulatively.

Production in Europe declines 4% on average each year to 2.4 mb/d in 2035. In Norway, despite expansion projects and brownfield developments, production falls by about 30% to 2035, and in the United Kingdom, it falls by 45%. Output from Africa declines by 0.7 mb/d to 2035, driven by more than 15% lower supply in Algeria and Nigeria, although recent discoveries in Côte d'Ivoire and Namibia progress towards development, while Uganda approaches first oil with advances on the East African Crude Oil Pipeline. In Russia, production falls from 10.6 mb/d in 2025 to 9.2 mb/d by 2035 and 8 mb/d by 2050 as sanctions and a lack of investment hamper the development of new greenfield resources in the Arctic, eastern Siberian and offshore regions to offset declines at mature West Siberian fields. In China, production declines from 4.5 mb/d in 2025 by more than 1 mb/d to 2035 as its resource base continues to mature.

Refining

Demand for refined products contracts by 3 mb/d in the STEPS, from 86 mb/d in 2025 to 83 mb/d in 2035.[1] Demand for gasoline and diesel drops by a combined 3 mb/d, as declines in advanced economies and China offset growth elsewhere. Road transport fuels have historically underpinned refining margins, so the fall in demand for these fuels poses a major challenge for refiners, who will face growing pressure to maintain profitability while adapting their product slates. Jet fuel and petrochemical feedstock demand continues to grow out to 2035, but rising NGL supplies meet most of the 2.5 mb/d increase in petrochemical feedstock demand to 2035, reducing the need for new refining capacity (Figure 4.34).

In the STEPS, 6 mb/d of new refining capacity comes online over the next decade, but this increase is largely offset by 5 mb/d of closures. Most additions are in Asia (especially in China and India) and in Africa, two regions where demand for refined products grows. Continued growth in petrochemical feedstock demand reinforces the shift towards integrated refining and petrochemical complexes, which benefit from economies of scale and lower operating costs. Closures are concentrated in Europe and the United States, where ageing facilities struggle to remain competitive without major retrofits. This creates a growing investment

[1] Refined products = liquid products excluding NGLs, CTL, GTL, additives and low-emissions fuels.

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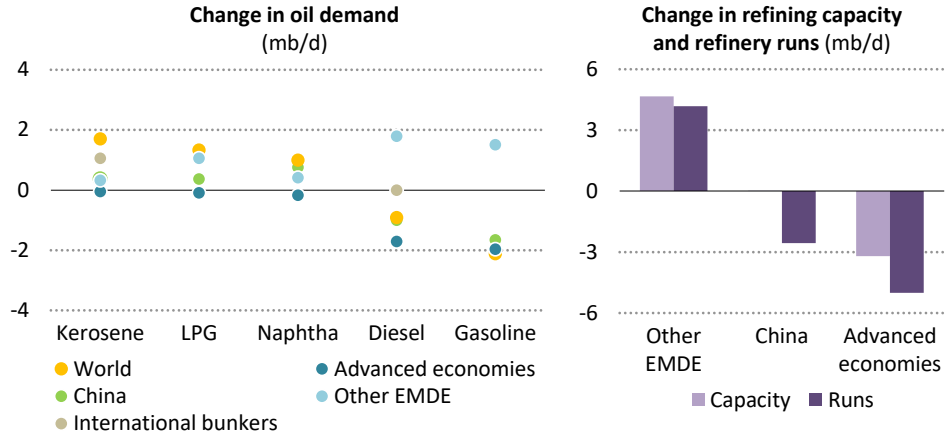
dilemma: while demand for some fuels is falling, it remains robust for others, and declining refinery throughputs could increase dependence on imports and exposure to supply and price shocks.

Figure 4.34 ▷ Change in demand for selected oil products, in refining capacity and refinery runs in the STEPS, 2025-2035



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Refinery capacity and runs grow where demand grows, and the changing product demand mix requires continuous adaptation of refinery yields across regions

Notes: LPG = liquefied petroleum gas. International bunkers are shown for kerosene and diesel only.

4.5.2 Natural gas

Demand

Natural gas demand in the STEPS grows at an average of 50 bcm per year between 2025 and 2035, which is below the average of 80 bcm per year over the past decade. Demand reaches a maximum level of around 4 800 bcm in the mid-2030s and remains around this level to 2050.

Demand for natural gas in advanced economies falls by nearly 40 bcm in aggregate between 2025 and 2035. A 70 bcm increase in demand in the United States is offset by a commensurate fall in the European Union, where the share of natural gas in the energy mix drops from 22% in 2025 to 19% in 2035, driven by policies aimed at accelerating electrification, renewables and energy efficiency across end-use sectors. Demand in Japan and Korea remains flat to 2035 as growth in nuclear and renewables cuts into gas use in the power sector.

Natural gas demand growth occurs mainly in emerging market and developing economies in Asia. Large importers such as China and India become opportunistic buyers and help to

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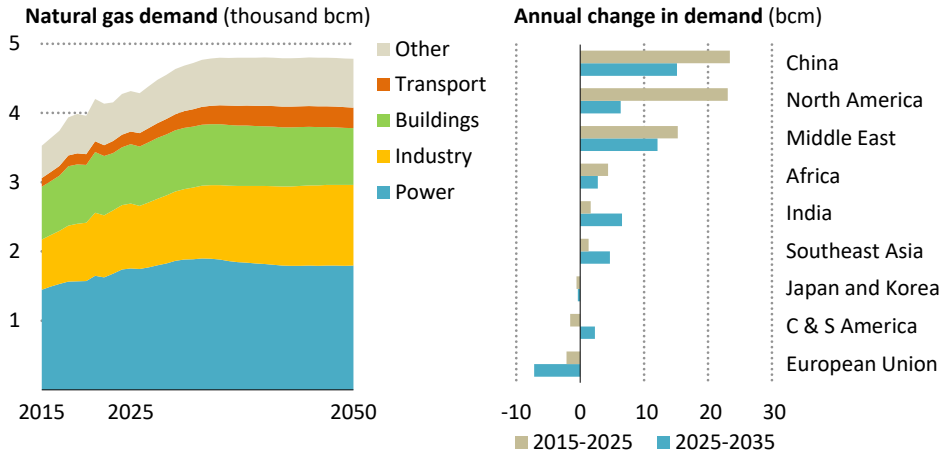
absorb part of the delayed LNG wave, but the space for natural gas to grow is narrowed by support for renewables, which reflects in part a wariness of excessive reliance on imported fuels (Figure 4.35).

Figure 4.35 ▷ Global natural gas demand by sector and average annual changes by region in the STEPS, 2015-2050



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In many regions, natural gas demand growth decelerates sharply to 2035 compared to the last decade

Note: Other includes energy own use and agriculture.

Supply

Natural gas supply reaches 4 800 bcm in 2035. Supply from conventional projects existing today totals around 1 700 bcm in 2035, while unconventional gas also contributes around 1 700 bcm (Figure 4.36). Projects that have been approved and are under development contribute around 650 bcm to supply in 2035. Meeting demand therefore requires around 750 bcm of supply from new projects that had not been approved for development as of 2026. This requirement for additional supply grows after 2035 as existing conventional supply declines further.

The United States is the single largest source of natural gas supply growth to 2035, buoyed by surging LNG exports as well as rising domestic demand. All of the incremental supply growth comes from unconventional gas, notably the associated gas from the liquids-rich Permian basin and the gas produced in the Haynesville and Marcellus fields. Signs of maturation are evident, however, and productivity gains slow over time. By 2050, US gas production falls back to 2030 levels. This trajectory still means that the United States maintains its position as the world's largest natural gas-producing country all the way through to 2050 (Figure 4.37).

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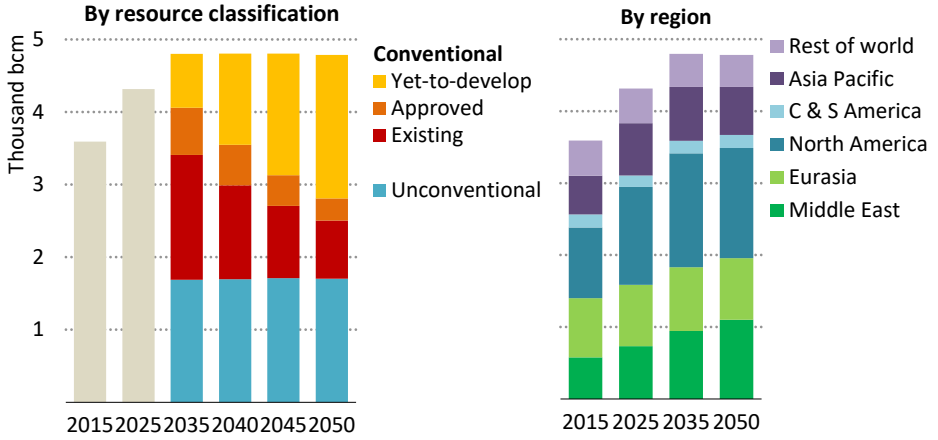
Figure 4.36 ▷ Natural gas supply by resource classification and region in the STEPS, 2015-2050



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Unconventional gas grows to 2035 and then stays flat; declining supply from existing and approved conventional projects means around 750 bcm of new supply is needed in 2035

Notes: Existing projects include extensions, such as infrastructure-led expansions. Approved projects are those that have reached a final investment decision as of 2026 and are scheduled to start production from 2026 onwards. Yet-to-develop supply includes discovered and undiscovered resources that are yet to be approved for development. See Annex C for definitions of unconventional gas.

In the STEPS, the Middle East sees the second-largest growth in supply to 2035, led by Qatar, Saudi Arabia and the United Arab Emirates. Qatar doubles its LNG capacity to 2035; despite a 12-month delay to start-up, all 87 bcm per year of new LNG export capacity comes online by the early 2030s, including the 22 bcm North Field West project, which is projected to start construction later this decade.

China is the third-largest contributor to global natural gas supply growth to 2035 in the STEPS, after the United States and Qatar. Despite challenging geology and surface-level constraints, the Sichuan basin continues to be a productive source of shale gas, while the Ordos basin yields additional tight gas and coalbed methane into the 2030s. Natural gas production in the rest of Asia Pacific declines by 65 bcm to 2035, as new developments in Indonesia and Malaysia are more than offset by declining output from mature fields in those countries and in Australia.

Natural gas production in Russia rises moderately from 660 bcm in 2025 to 670 bcm in 2035, to meet domestic demand growth. Exports to the European Union dry up in line with the REPowerEU plan, and Russia struggles to find additional export outlets; pipeline exports to China do not exceed 55 bcm per year, and export growth into Central Asia is modest. Falling profits, meanwhile, limit upstream investment, and production declines at mature fields such as Urengoy and Yamburg. Turkmenistan also faces limited opportunities to expand exports, with subdued Chinese import requirements reducing the incentive to develop all planned phases of the supergiant Galkynysh field.

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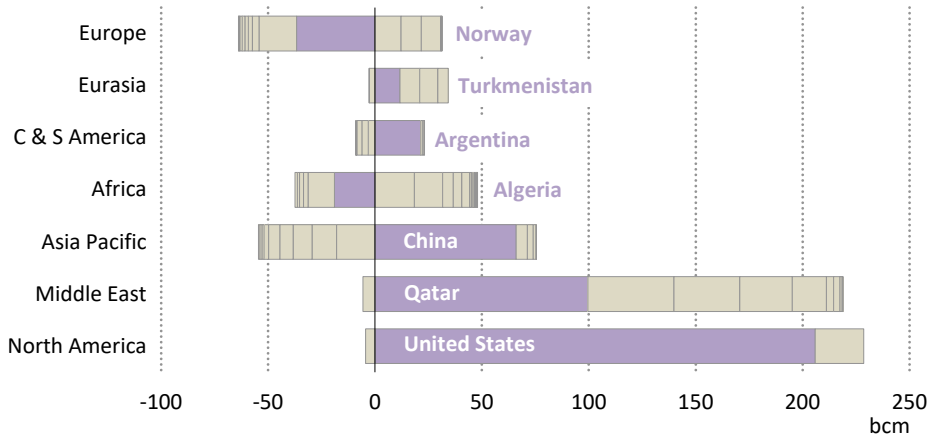
Figure 4.37 ▷ Change in natural gas supply by country in the STEPS, 2025-2035



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The United States sees the largest increase in natural gas supply of any country

Gas production in Europe falls by around 13% (30 bcm) by 2035. The commissioning of new offshore developments in the Black Sea and Eastern Mediterranean region is more than offset by decreases in other fields, notably in Norway, where production declines between 2025 and 2035 by more than 30% (nearly 40 bcm).

Many countries in Africa see production grow as resource discoveries over the past decade come to the market and streamlined regulations incentivise additional private sector investment. Mozambique sees the largest growth in sub-Saharan Africa, followed by Nigeria. Congo, Libya and Tanzania also record growth. In North Africa, Egypt's Zohr field continues to struggle with reservoir pressure and water encroachment, and new developments only partially offset further decline. In Algeria, gradually declining output from the giant Hassi R'Mel field offsets gains from smaller fields.

In South America, Argentina emerges as a large gas and LNG producer, although limited local market growth and the time needed to build greenfield export infrastructure moderate the pace of development of Vaca Muerta's vast unconventional gas resources.

Trade

Around 1 100 bcm of natural gas was traded over long distances in 2025, which was around 30% more than in 2015.[2] A tight global gas market over the past several years has given developers confidence to green-light new projects, and around 300 bcm of LNG export capacity has been approved for investment since Russia's full-scale invasion of Ukraine. This

[2] Long-distance pipeline trade refers to trade between 20 macro-regions in the Global Energy and Climate Model (GECM) (IEA, 2026e). For more information, see the model documentation.

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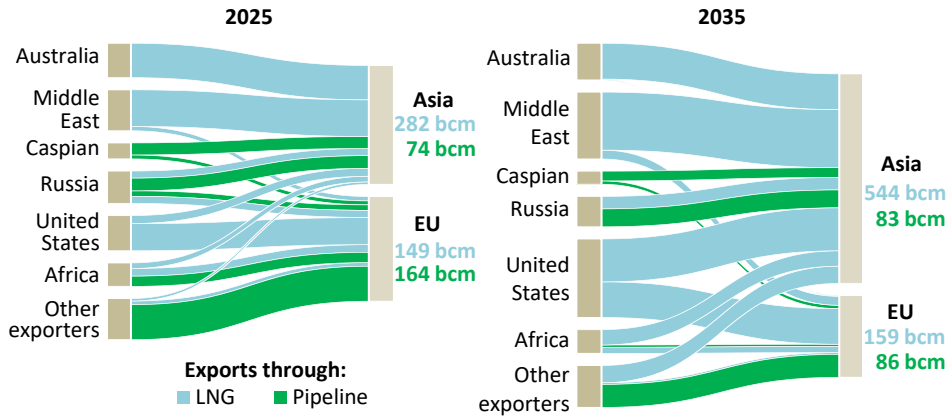
will in effect increase global capacity in 2030 by 50% from its level in 2022, despite declines in output at legacy plants in Algeria, Brunei, Indonesia, Malaysia, Papua New Guinea, and Trinidad and Tobago. Taking into account retirements at existing plants and under-construction projects, LNG capacity appears more than sufficient to ensure market supply and resilience in the STEPS through to the end of the 2030s. Asia is the destination for around 70% of global LNG exports in 2035, up from 60% in 2025 (Figure 4.38).

Figure 4.38 ▷ Natural gas exports to the European Union and Asia in the STEPS, 2025 and 2035



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LNG dominates growth in global gas trade, with the United States accounting for the largest increase in exports and Asia growing its share of overall trade

Notes: EU = European Union; LNG = liquefied natural gas. Other exporters include Norway as well as Indonesia, Malaysia and other Asian exporting countries.

This wave of new LNG supply brings lower prices, but it arrives against a backdrop of increased hesitancy among price-sensitive importers in Asia about taking long-term investment decisions on new gas infrastructure, especially in the context of the conflict in the Middle East. The implication is an overhang of LNG supply which peaks around 2030 and falls to around 70 bcm in 2035. Lower prices generate only limited long-term demand response, and infrastructure constraints restrict importers' ability to absorb additional LNG volumes. Lower utilisation is particularly evident among North American export facilities, which generally have the greatest flexibility to adapt to changes in market conditions.

Despite the headwinds, LNG trade between regions expands by 260 bcm by 2035 (an annual average growth rate of around 4%), running well ahead of overall global gas demand growth (1% per year). Around one-quarter of this growth delivers the imports needed to replace declining domestic gas production among key importers, in particular Europe, Bangladesh, Pakistan and parts of Southeast Asia; the remainder meets new and growing natural gas demand, with China and India serving as the two largest growth markets (Figure 4.39). China

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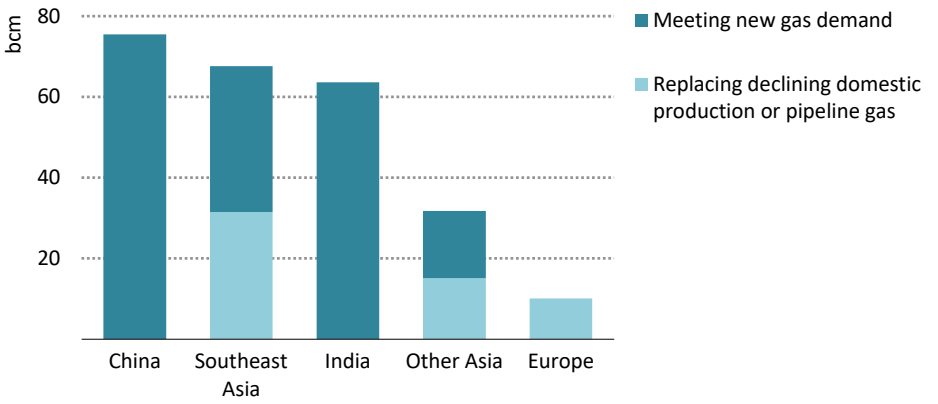
imports an additional 85 bcm of natural gas in 2035 in the STEPS compared with today, and most of this growth is met by LNG. India imports a further 65 bcm in 2035, all of which is met by LNG.

Figure 4.39 ▷ Drivers of growth in LNG demand in selected regions in the STEPS, 2025-2035



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One-quarter of projected growth in LNG demand replaces declining domestic production or pipeline imports in key importing regions; the rest meets new gas demand

Another major outlet for gas trade is Southeast Asia, which flips from net exporter to net importer later this decade. Almost half of the increase in LNG demand growth in Southeast Asia replaces declining domestic production, notably in Indonesia, Malaysia and Thailand, and the other half meets growing new gas needs, notably in the Philippines and Viet Nam. Although gas demand in the European Union falls 20% by 2035, LNG imports remain similar to 2025 levels, helping to offset declining domestic production and pipeline supplies. Gas imports in Japan and Korea stay relatively flat to 2035.

4.5.3 Coal

Demand

Global coal demand has grown by around 3% per year on average since 2000, though the rate of growth has slowed in recent years. In the STEPS, demand falls by 14% from 6 165 Mtce today to around 5 280 Mtce by 2035 (Figure 4.40). Coal's share of global energy demand falls from over 25% in 2025 to around 20% in 2035, which is similar to the contribution of renewables in that year.

The power sector, which accounts for two-thirds of coal demand today, drives most of this decline, with coal-fired generation falling by around 15% by 2035 as renewables gain market share. China is the main driver: its power sector consumes over 2 250 Mtce of coal today,

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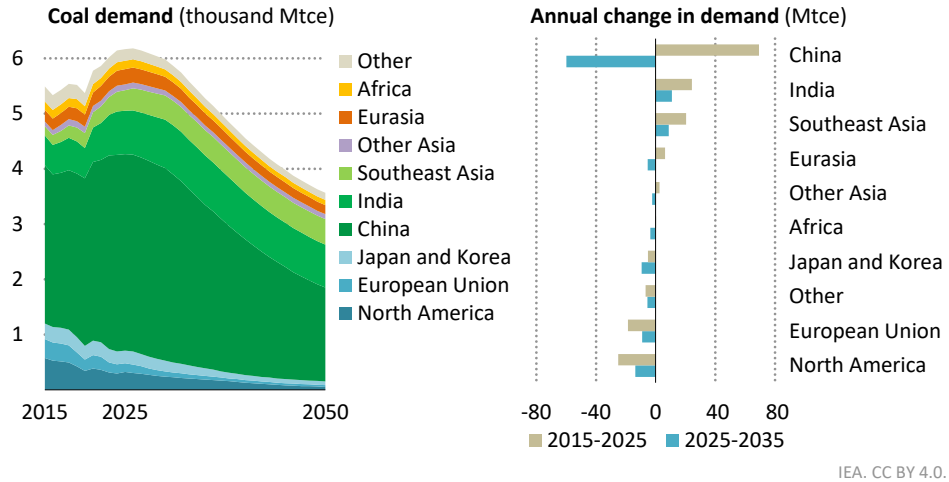
which is more than the total in all other countries' power sectors combined. Despite continued capacity additions, coal in China shifts from providing baseload generation towards providing flexibility and reserve capacity, causing power sector coal use to drop by just under 20% by 2035. India and Southeast Asia are the only major regions where coal-fired generation grows in the STEPS. In India, it rises by 15% to 2035 and in Southeast Asia by almost 30%, driven increasingly by industrial activity and captive generation, particularly for aluminium production and nickel processing in Indonesia.

Figure 4.40 ▷ Global coal demand and average annual changes by region in the STEPS, 2015-2050



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Falling coal use in China's power sector and steel industry brings a turning point in global coal demand, although developing Asia remains a source of growth

Notes: Mtce = million tonnes of coal equivalent. 'Other' contains Central and South America, the Middle East, Australia, New Zealand and the rest of Europe.

Industrial coal demand falls more gradually than power sector demand, declining by around 5% to 2035. China's chemicals sector continues to underpin coal demand; it already consumes more coal than the entire EU power sector, and coal use for coal-to-liquids and coal-to-gas production more than doubles to 2035. Coking coal demand remains robust where blast furnace production continues to expand, notably in India, Southeast Asia and parts of Africa, partly offsetting a 25% decline in coal use for steel production in China.

Coal demand declines faster over the next decade in advanced economies, where it decreases by 45%, than in emerging market and developing economies, where it falls by 10%. Despite some delayed coal plant retirements in Europe and the United States, demand continues to fall as renewable generation in advanced economies expands by nearly 80% to 2035.

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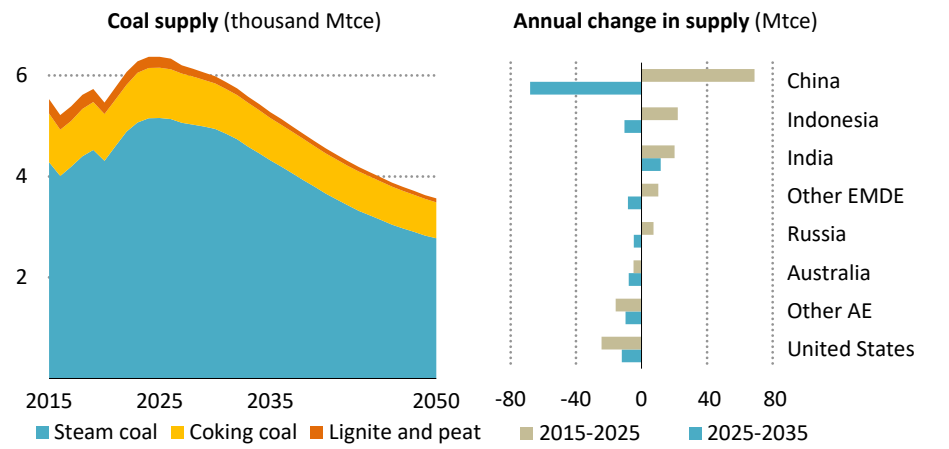
Supply

Global coal production in 2025 reached a new high of 6 375 Mtce as continued growth in China offset flat or declining output from several other major producers. In the STEPS, global coal production starts to decline in the next few years, falling to around 5 275 Mtce by 2035 and 3 565 Mtce by 2050 (Figure 4.41). This decline is led by steam coal, which accounts for more than 80% of the coal produced today and is mainly used for power generation and industrial heat.

Figure 4.41 ▷ Coal supply by type and average annual changes in supply by region in the STEPS, 2015-2050



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After reaching record highs in 2025, global coal production enters a long-term decline, with falling output in China and other major producers outweighing near-term growth in India

Note: AE = advanced economies; EMDE = emerging market and developing economies.

China remains the dominant force in global coal supply, accounting for half of production today. It is also the biggest contributor to the decline in global output seen in the STEPS. Following several years of record production, China's coal output falls from around 3 365 Mtce to 2 685 Mtce by 2035. Even so, China remains the world's largest producer, reflecting the scale of its domestic coal sector, which includes coal bases in Inner Mongolia, Shanxi and Xinjiang.

India is one of the few countries where output continues to grow over the next decade. Production rises from around 580 Mtce to 695 Mtce by 2035. Growth is supported by policies to strengthen domestic supply, with production from Coal India, as well as captive and commercial mines, building on major resources such as Gevra – set to become the largest mine in the world – and new commercial mining blocks. As demand plateaus in the 2030s, production gradually eases, but India remains the world's second-largest producer in 2050.

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Production in the major exporting countries comes under pressure as import demand weakens, particularly in Asia. Indonesia, the world's largest steam coal exporter, sees output fall from 565 Mtce to 465 Mtce in 2035 because of lower export demand, especially from China, which currently absorbs almost half of Indonesia's exports. Changes to export administration, including the establishment of the state-owned export company Danantara Sumberdaya Indonesia, underline the government's efforts to exert greater control over coal exports.

Russia sees export opportunities diminish and domestic demand weaken, with output falling from 360 Mtce in 2025 to 310 Mtce by 2035 as its producers continue to face pressure from weaker prices, transport bottlenecks and the need to redirect exports towards Asian markets following the loss of traditional European customers. In South Africa, output falls from 190 Mtce to just under 150 Mtce over the same period because of power plant closures combined with weaker export demand.

Coal production in advanced economies continues its long-term decline, as many producers in this group saw output peak in the 2010s. Output from advanced economies falls by 30% to 2035, with 40% of the decline taking place in the United States and the remainder in Australia, Colombia and Europe. US production falls from 370 Mtce to 250 Mtce by 2035 as coal demand in the power sector contracts and export markets shrink. Australia sees a more gradual decline from 380 Mtce to 300 Mtce by 2035, reflecting the continued importance of coking coal in international markets.

Trade

International coal trade declined in 2025 as China's imports fell back, more than offsetting growth in parts of Southeast Asia and other importing countries. Chinese Taipei, Japan and Korea are among the largest importers today, but their demand declines over time. China, India and other developing Asian economies account for the largest share of imports by 2050. Australia, Indonesia and Russia continue to dominate exports. In the near-term, coal trade temporarily stabilises as high gas prices and energy security concerns support some gas-to-coal switching in import-dependent power systems. Tightness in parts of China's domestic market, including for coking coal, also boosts imports. At the same time, changes to Indonesia's coal export arrangements add uncertainty to steam coal trade flows. The declaration of force majeure at Colombia's Cerrejón mine in June 2026 further reshapes trade patterns, as European buyers seek alternative sources of steam coal to replace what had been one of the continent's largest suppliers after the collapse of trade from Russia.

Coal trade declines from around 1 160 Mtce today to 950 Mtce in 2035 and 760 Mtce in 2050 (Figure 4.42). China's imports fall by 80 Mtce to 2035 – equivalent to half of the European Union's total coal demand today – as coal use declines and strong production continues to supply over 90% of domestic demand, although imports remain attractive in some coastal markets. Imports by Chinese Taipei, the European Union, Japan and Korea continue to decrease as coal-fired generation is displaced by low-emissions sources. India becomes increasingly important to global coal trade, with coking coal imports rising to 2050 as demand in industry continues to grow.

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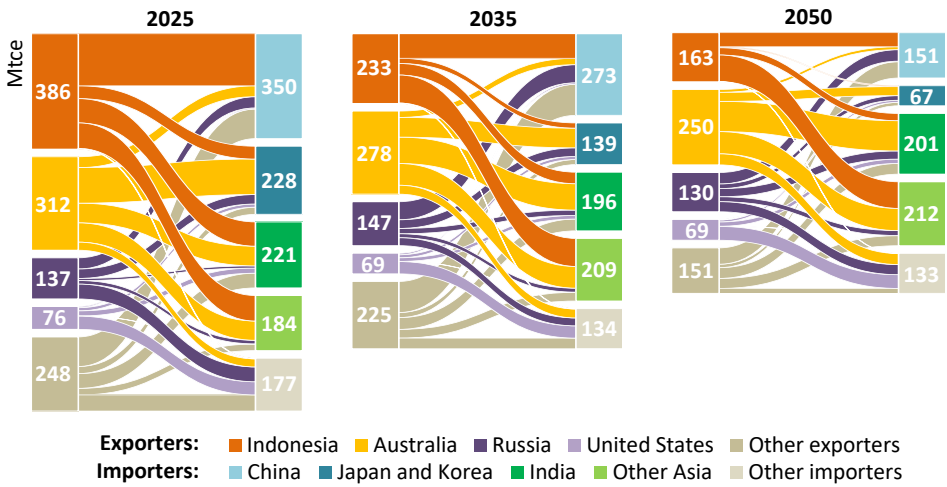
Figure 4.42 ▷ Net coal trade in the STEPS, 2025-2050



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Contracting coal trade sees Australia overtake Indonesia as the largest exporter, supported by robust coking coal demand in India

Note: The largest coal exporters and importers are ordered by net coal trade in energy-equivalent terms in 2025. 'Other exporters' include South Africa, Mongolia, Colombia, Canada, Caspian, Mozambique, New Zealand and Venezuela; 'Other importers' include Europe, the Middle East, North Africa, and the rest of Latin America and sub-Saharan Africa.

Steam coal trade contracts by a quarter to 2035, while coking coal trade rises slightly. Indonesia and Colombia are among the exporters most exposed to declining steam coal demand, while Australia's export profile is more resilient because of its larger role in coking coal markets. Russia faces declining exports as demand weakens in key markets and producers remain under financial pressure. Over time, international coal trade becomes smaller and more concentrated, with a greater share linked to coking coal and to countries where domestic coal quality or geography requires imports to supplement local production.

4.5.4 Low-emissions fuels

Modern bioenergy

Modern bioenergy demand grows in the STEPS from 45 EJ in 2025 to 56 EJ by 2035.[3] Solid fuels, such as wood pellets, account for 85% of total modern bioenergy today. This share decreases to 80% by 2035.

Biogases are the smallest form of modern bioenergy today, but grow quickly in the STEPS, reaching around 80 billion cubic metres of natural gas equivalent (bcme) globally by 2035, of

[3] A further 20 EJ of the traditional use of solid biomass was consumed in 2025.

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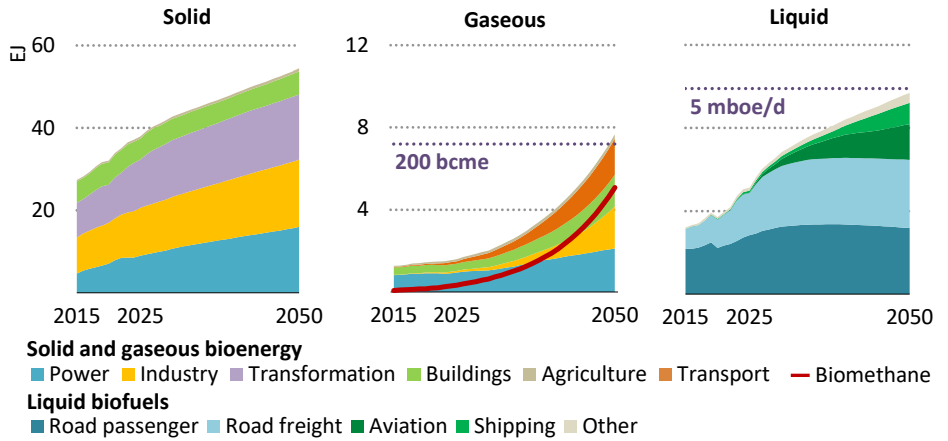
which around 40% is upgraded to biomethane (Figure 4.43). The European Union accounts for one-third of global biogases consumption in 2035, followed by China, the United States and India, where consumption increases almost sixfold. Significant untapped biogas potential remains: production from non-food feedstocks could meet more than 20% of global natural gas demand while reducing emissions and strengthening energy security (IEA, 2026f). However, biogases generally have higher costs than fossil fuels or electrification options. This cost gap leaves blending mandates as the main driver of growth.

Figure 4.43 ▷ Modern bioenergy demand by type and sector in the STEPS, 2015-2050



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Solid bioenergy remains the most used form of modern bioenergy, but biomethane is the fastest growing to 2050

Notes: bcme = billion cubic metres of natural gas equivalent; mboe/d = million barrels of oil equivalent per day. Transformation is energy consumed converting primary bioenergy into usable final forms. Gaseous modern bioenergy includes biogas and its upgraded form, biomethane. Other includes agriculture, industry and rail.

Around 2.6 million barrels of oil equivalent per day (mboe/d) of modern liquid biofuels were produced in 2025, nearly all of which was used in road transport. This grows to 3.9 mboe/d in 2035. The United States is the largest producer today (25% of global production), followed by cereal- and sugar-cane-producing Brazil (15%), oil-crop-producing Southeast Asia and rapeseed-producing Europe (9% each). The 2026 energy crisis gave a boost to biofuel policies in several countries, with Indonesia, for example, raising its biodiesel mandate to 50% by volume from July 2026. Liquid biofuel use in aviation and shipping rises from marginal levels today to 1.4 mboe/d by 2050: more than 60% of this is consumed in the European Union, supported by measures such as ReFuelEU Aviation and the FuelEU Maritime regulation.

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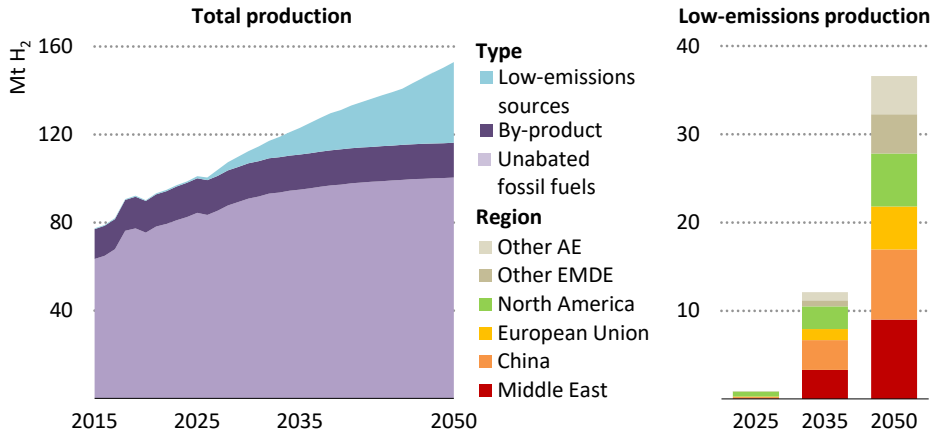
Low-emissions hydrogen

Global hydrogen production rose to over 100 Mt in 2025. Around 84% of the total was produced from unabated fossil fuels (Figure 4.44), and around 15% was a by-product from processes in refining and the chemicals industry. Less than 1% was produced from low-emissions sources, although output from these sources increased by 20% in 2025. Around 80% of this low-emissions hydrogen was from fossil fuel facilities retrofitted with carbon capture, utilisation and storage (CCUS), and around 20% was produced via electrolysis paired with low-emissions electricity.

In the STEPS, total hydrogen production rises to around 125 Mt in 2035 and 155 Mt in 2050. Demand remains concentrated in refining and industry, while emerging uses such as biofuels and hydrogen-based fuels production, transport and power generation reach 7 Mt by 2035. Installed capacity of electrolysers surges from 4 GW in 2025 to nearly 80 GW in 2035, enabling 8 Mt of hydrogen to be produced with low-emissions electricity, mostly in China, the Middle East and the European Union. This expansion in installed capacity is supported by rapid growth in electrolyser manufacturing capacity, led by China. Hydrogen production from fossil fuels with CCUS reaches 4 Mt in 2035, six times higher than in 2025, with most output located in the Middle East and North America.

Figure 4.44 ▷ Hydrogen production by type and low-emissions hydrogen production by region in the STEPS, 2015-2050



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Low-emissions hydrogen represents less than 1% of total hydrogen production today but accounts for the majority of growth from 2030 onwards

Notes: Mt H_2 = million tonnes of hydrogen. By-product hydrogen is excluded from the IEA low-emissions hydrogen definition (see Annex C).

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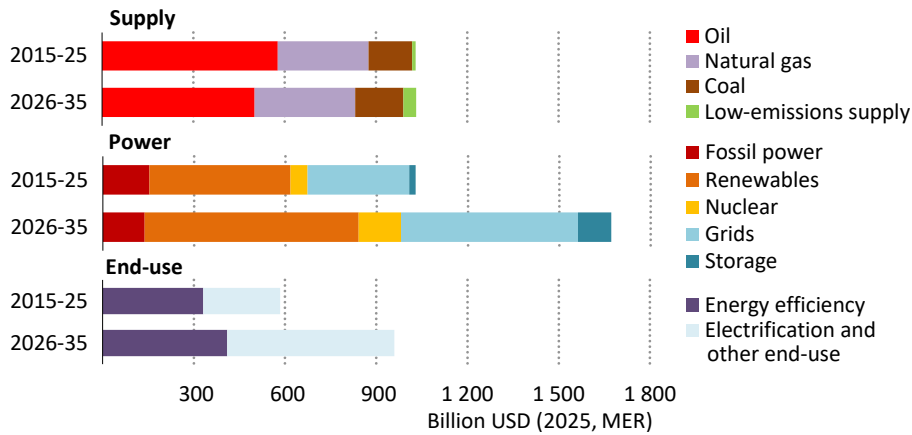
4.6 Investment

Energy investment in the STEPS averages USD 3.7 trillion annually over the next decade (Figure 4.45). Investment in energy supply averages USD 1 trillion per year. Relative to the annual average in the previous decade, spending on oil supply falls by 13% to USD 500 billion per year. Meanwhile, investments in natural gas and coal supply both increase by 10%, with gas spending reaching USD 330 billion per year and coal spending approaching USD 160 billion. Investment in low-emissions supply almost quadruples from a low base to over USD 40 billion per year.

Figure 4.45 ▷ Average annual energy investment in the STEPS, 2015-2035



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Energy investment in the STEPS grows 40% to 2035 compared to the last decade; two-thirds of this growth comes from additional spending on renewables, nuclear, grids and storage

Note: low-emissions supply = modern bioenergy, low-emissions hydrogen, low-emissions hydrogen-based fuels and direct air capture.

The power sector averages nearly USD 1.7 trillion per year and accounts for 45% of investment. Generation investment rises by 45% to USD 985 billion annually to 2035 relative to the previous decade, led by a 30% increase in solar PV investment to USD 345 billion and a 70% rise in wind investment to nearly USD 240 billion. Nuclear investment more than doubles to USD 140 billion on average to 2035, driven by a resurgence in activities among advanced economies. Investment in gas generation remains elevated through this decade, driven in part by rising electricity demand from data centres in advanced economies, before declining in the 2030s. Spending on coal generation declines gradually in the next decade across regions, as capacity additions fall by over 70% in this period. Transmission and distribution investment increases by 75% to USD 580 billion per year, and battery storage investment grows more than fivefold to an average of USD 110 billion per year, of which USD 78 billion is spent on utility-scale battery systems (Box 4.8).

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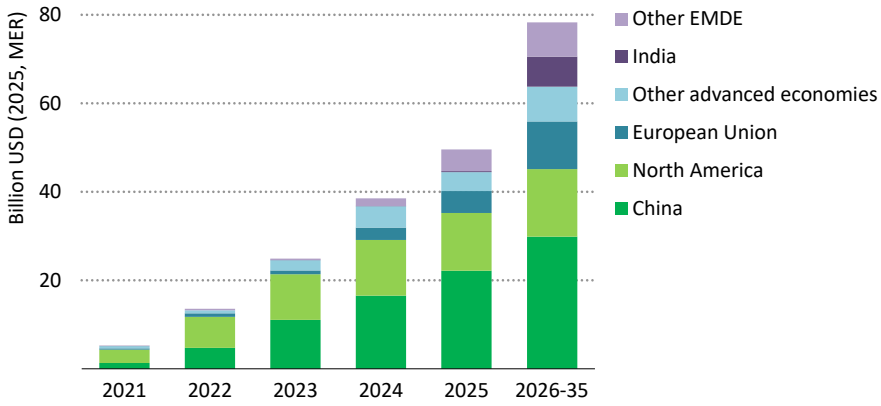
Box 4.8 ▷ Evolving remuneration models for utility-scale battery systems

Battery energy storage systems (BESS) support the integration of rising shares of renewables, while also providing congestion management and other ancillary services, and are becoming a key source of flexibility. Investment in utility-scale BESS rose from around USD 2.5 billion in 2020 to nearly USD 50 billion in 2025, and it increases in the STEPS to average USD 78 billion per year over the next decade (Figure 4.46).

Figure 4.46 ▷ Average annual investment in utility-scale battery energy storage systems by region in the STEPS, 2021-2035



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Investment in utility-scale BESS grows to average USD 78 billion per year to 2035; India is one of the fastest-growing markets, with spending averaging USD 7 billion

The rise of utility-scale BESS has been accompanied by the continued evolution of revenue streams and business models. In liberalised markets such as Australia and parts of the United States, business models range from fully merchant projects, whose owners rely directly on market revenues, to tolled merchant projects, which provide investors with more predictable contracted revenues in exchange for transferring dispatch rights and much of the market risk and potential upside to a counterparty. Access to ancillary service markets has improved in many countries, for instance in Poland, where reforms in 2024 opened balancing services to batteries. As deployment increases, falling margins from saturated capacity and ancillary service markets are triggering a shift towards energy arbitrage as the primary revenue stream. Revenue stacking is becoming more essential to the bankability of projects in such markets. By allowing assets to earn income from multiple services, revenue stacking enables asset owners to better capture the full system value of storage and reduce reliance on any single income stream.

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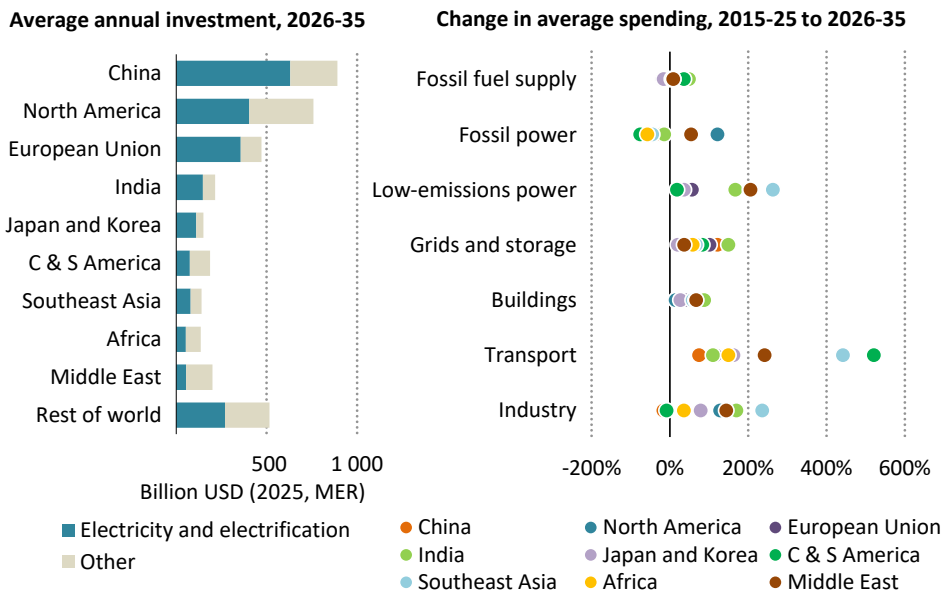
Investment in energy efficiency, electrification and other end uses averages USD 960 billion per year over the next decade, which is 65% higher than in the previous decade. Spending on end-use electrification, primarily in the transport sector, more than doubles to USD 510 billion per year. Investment in energy efficiency grows more modestly, rising by 25% to USD 410 billion per year.

China maintains its position as the world's largest energy investor, averaging nearly USD 900 billion per year to 2035, around 70% of which is spent on electricity and electrification. Investment in low-emissions power grows by 50% to 2035, but at a slower rate than in the previous decade. Investment in electricity and electrification rises by more than 60%, while investment in fossil fuel supply declines by 5% (Figure 4.47).

Figure 4.47 ▷ Average annual energy investment and change in spending by region in the STEPS, 2015-2035



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China leads spending in the next decade; investment in electricity and electrification rises most steeply in India, Southeast Asia and Africa

Note: Other includes fossil fuel supply, energy efficiency and other end-use.

Investment in low-emissions power gains momentum in emerging market and developing economies. In Southeast Asia, annual investment more than triples in the next decade relative to the previous, with growth spread across solar PV, wind, hydropower and geothermal, while investment in fossil power almost halves to an annual average of USD 7 billion. In India, investment in low-emissions power nearly triples to 2035, reaching

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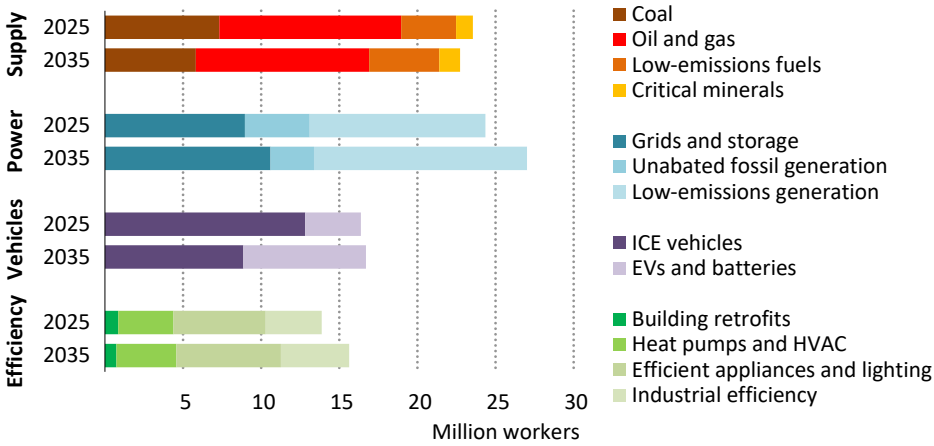
almost USD 60 billion per year. Renewable energy capacity additions are supported by a more than doubling of spending on grids and storage.

End-use investment has so far been concentrated in advanced economies and China, but the next decade sees rapid growth across the board. Electrification of transport is the main driver of growth in end-use investment, with spending rising fastest in Central and South America, and in Southeast Asia. Industrial energy efficiency and electrification are particularly important in regions with ambitions to become global manufacturing hubs, and Southeast Asia's investment in industrial end-use nearly triples. The European Union maintains its position as the largest investor in the buildings sector, with spending averaging nearly USD 115 billion per year, but buildings investment in emerging market and developing economies grows rapidly as rates of urbanisation and electrification rise. For example, investment grows by 90% in India, while spending in Africa, and Central and South America grows by two-thirds.

4.7 Employment

In the STEPS, energy employment grows steadily from today's historically high levels through to 2035, supported by sustained investment in energy infrastructure. While employment growth slows from the 1% average rate seen over the past decade, the sector continues to add jobs, with total employment rising by 0.5% annually to reach 82.1 million in 2035.

Figure 4.48 ▷ Global energy employment by sector in the STEPS, 2025 and 2035



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The energy sector adds 3.9 million new workers by 2035, with the power sector seeing the largest gains

Note: HVAC = heating, ventilation and air conditioning.

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The emergence of the Age of Electricity has been visible in employment trends in recent years. The power sector overtook energy supply sectors in the first half of the 2020s to become the largest energy employer, with 24.3 million jobs (Figure 4.48). Employment in the power sector continues to grow to 2035, although at a slower pace than in the previous decade, and the total number of jobs increases by a further 2.7 million to reach 27 million. Grids and storage account for 1.6 million of these additional jobs, and low-emissions generation adds a further 2.4 million jobs – although these gains are partly offset by a contraction of 1.4 million jobs in unabated fossil generation.

Overall, this leads to a significant slowdown in job growth in power generation compared to the previous decade. This reflects slower generation capacity additions, especially in China, together with declining labour requirements per GW as technology costs fall and economies of scale increase. Employment linked to the construction of new power generation projects begins to plateau over the next decade, but jobs associated with the operation of installed capacity continue to grow by nearly 4% per year, close to the rate seen over the previous decade.

Employment in fossil fuel supply enters a gradual decline in the STEPS, falling from 19 million jobs in 2025 to 16.9 million by 2035. Coal accounts for most of the reduction as coal demand from power generation is increasingly displaced by renewables and other sources, with coal supply jobs falling by 1.5 million to 5.8 million by 2035. Oil and gas employment falls by 560 000 jobs to 11.1 million by 2035 as investment levels begin to fade in the 2030s. In contrast, employment in low-emissions fuels (including modern bioenergy, hydrogen and nuclear fuels) and in critical minerals supply continues to grow, rising by 1.2 million to a total of 5.8 million jobs by 2035. EV and EV battery manufacturing account for nearly half of total vehicle manufacturing employment by 2035 as the EV share of global sales increases. Overall employment in vehicle manufacturing stabilises at around today's level over the coming decade, as increasing labour productivity in EV and battery manufacturing counteracts the trend of rising vehicle sales. Employment in energy efficiency also grows steadily along with investment.

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Potential additional responses

Importer and exporter perspectives

SUMMARY

- Responses to the energy crisis stemming from the conflict in the Middle East could go beyond those incorporated into the Current Policies Scenario (CPS) and Stated Policies Scenario (STEPS), especially if there is a long tail of risks affecting oil and gas production and trade in the region. We explore this possibility in the Additional Response Case (ARC), as well as how quickly the world could reduce its reliance on oil and gas flows through the Strait of Hormuz in a Low Hormuz Case (LHC). These cases investigate a world in which there is less confidence than before in a well-functioning system of international energy trade. The analysis focuses on actions countries are considering but have often not yet formalised in legislation or detailed proposals.
- The ARC includes efforts, primarily in fuel-importing countries, to diversify routes and sources of supply; to encourage greater use of domestically available resources, including energy efficiency; and to electrify end-uses more quickly. Policy signals for faster electrification are widespread, including in China, the European Union, India, Japan, Korea and Southeast Asia, and they could strengthen if energy security and geopolitical concerns persist.
- Oil demand in the ARC in 2035 is about 4.4 million barrels per day (mb/d) lower than in the STEPS. Oil product trade falls faster than crude oil trade as importers seek to boost domestic production and expand refining capacity, but there is still scope for some trusted producers to expand exports as importers focus on security and diversity. Gas demand grows, but at a slower pace than in the STEPS. Importing regions see the largest differences compared with the STEPS.
- Electric vehicles displace more than 11 mb/d of oil demand in the ARC by 2035, and heat pumps, building retrofits and efficiency improvements all grow faster than in the STEPS. Gas-importing regions meet higher electricity demand mainly through solar photovoltaics, wind, nuclear and coal, which together produce around 1 200 terawatt-hours more electricity in 2035 than in the STEPS, requiring the faster expansion of grids and storage.
- In the LHC, a suite of measures reduces the need for transit through the Strait to 2 mb/d in 2035, compared with 20 mb/d in that year in the STEPS. Over 60% of this difference comes from the establishment of routes that bypass the Strait (including existing, under-construction and proposed pipelines), while 15% comes from higher oil production outside the Middle East. The remainder is from demand-side measures, as in the ARC. While there are no routes open for liquefied natural gas (LNG) to bypass the Strait, a wave of new LNG export capacity being built outside the Middle East could also significantly reduce dependence on the waterway.

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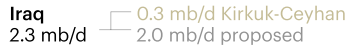
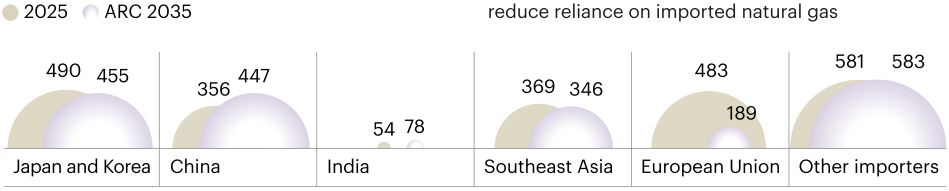
Differences in oil flows through the Strait of Hormuz in the LHC relative to the Stated Policies Scenario in 2035

Chapter 5 explores the potential implications of the crisis for energy markets and security. The Low Hormuz Case (LHC) examines a prolonged disruption to oil flows through the Strait of Hormuz and the alternative routes and responses available.

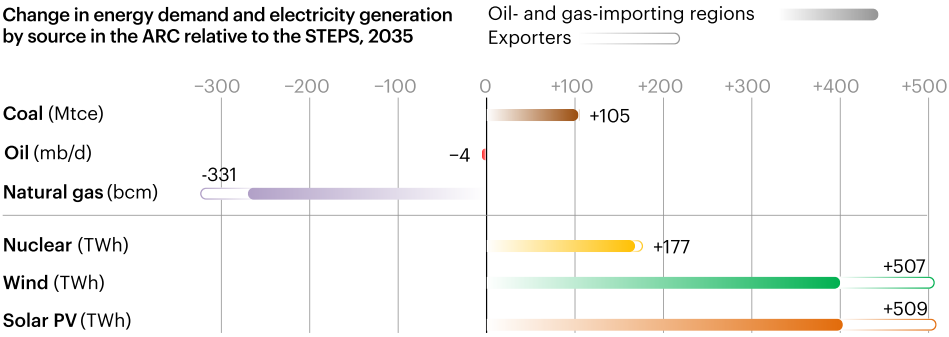


Natural gas-fired generation, TWh

The Accelerated Response Case (ARC) explores measures under consideration in fuel-importing and exporting countries, including faster electrification and diversifying supply routes and sources. In the power sector, more renewables, nuclear and coal reduce reliance on imported natural gas



Change in energy demand and electricity generation by source in the ARC relative to the STEPS, 2035



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5.1 Introduction

The implications of the conflict in the Middle East for the energy outlook could go well beyond those described in the Current Policies Scenario (CPS) and Stated Policies Scenario (STEPS). A second major crisis affecting oil and natural gas supply in the space of five years has underscored the vulnerability of many fuel-importing regions[1] to geopolitical shocks and supply disruptions, particularly where energy supplies depend on a limited number of suppliers, transit routes or strategic chokepoints. It also opens new challenges and opportunities for fuel-exporting countries. At the time of writing, the crisis is not over; the longer it lasts, the more likely it is to prompt reassessments of energy strategies, investment plans and risk management frameworks. Market conditions may stabilise over time, but governments in both importing and exporting countries may conclude there can be no return to the assumptions that existed before the crisis.

The potential for additional responses by both fuel importers and exporters is taken up in this chapter:

- An **Additional Response Case (ARC)** is grounded in what governments have said they are considering. For fuel-importing countries, the emerging focus is on measures that address vulnerabilities revealed by the crisis. Many countries, first and foremost in Asia, had become heavily dependent on supplies delivered through the Strait of Hormuz. These countries are now considering ways to develop more homegrown energy resources and to diversify fuels, suppliers and routes.
- A **Low Hormuz Case (LHC)** presents specific analysis on how quickly actions by producers and consumers could reduce reliance on the transit of energy through the Strait of Hormuz.

These strategic reassessments come on top of broader trends already underway following the energy crisis of 2021-2023. As described in Chapter 2, investment patterns in fuel-importing countries have shifted in recent years towards technologies that reduce dependence on imported oil and gas. Investment in coal supply has picked up in some parts of Asia as a result, while renewables, nuclear power, electricity networks, batteries, electric vehicles (EVs) and energy efficiency have all benefited more broadly from this trend. This brings into view some new dependencies, as the supply chains for many of these technologies are highly concentrated. But events of 2026 could nonetheless give these shifts additional momentum.

Although governments have largely focused on managing the immediate impacts of the current crisis, some early indications of longer-term policy responses are beginning to emerge in speeches, strategic reviews, announcements and public statements. These responses span demand, power sector and fuel supply policies (Table 5.1). In many cases,

[1] Fuel-importing regions in this chapter are net importers of fuels, where imports exceed exports. This classification is based on 2025 energy trade and follows the level of granularity in the IEA's Global Energy and Climate Model (IEA, 2026).

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the measures under discussion have not yet been translated into formal legislation or detailed implementation plans, so they are not included in the CPS or the STEPS. Nevertheless, they indicate how countries may respond if concerns about the security of supply and geopolitical risk persist.

Table 5.1 ▷ Emerging policy responses to the 2026 energy crisis

Policy goal	Policy form	Examples
Reducing fuel import dependence	Energy self-sufficiency targets; lower import shares; diversification of crude, gas and product suppliers.	Self-sufficiency or import reduction indications in Bangladesh, China, India, Indonesia, Lithuania, Spain, the United Kingdom and others; India also highlights broader crude oil supply diversification and refining capacity.
Adding export routes	Commitments to build additional export infrastructure for oil and gas, including projects to reduce reliance on the Strait of Hormuz.	Planned new pipeline routes in the Middle East and a potential west coast pipeline project in Canada; faster permitting of new projects in the United States.
Accelerating demand-side electrification	Faster electrification of transport, buildings and selected industry; EV targets and electrification strategies.	Accelerated electrification plans in many economies, notably among those in South and Southeast Asia most affected by the crisis.
Expanding efficiency and fuel-saving measures	Energy efficiency standards, conservation measures, industrial efficiency and building efficiency programmes.	Enhanced efforts to increase energy efficiency by many importers, including in China, the European Union, India, Indonesia, Japan, Korea and the Association of Southeast Asian Nations (ASEAN).
Scaling domestic low-emissions power	Faster deployment of renewables, nuclear, grids, storage and flexibility resources.	Signals of greater interest in renewable power and, in some cases, nuclear among major importers such as the European Union, India, Japan and Korea.
Using domestically available fuels	Support for domestic fossil fuel supply, as well as biofuels and biomethane.	Support for in-country investments in Bangladesh, Egypt, Thailand, Türkiye and Viet Nam; biofuel/biomethane measures in India and ASEAN.
Building buffers and resilient fuel infrastructure	Building up or expanding strategic oil stocks, commercial inventories, gas storage and refinery capacity.	Oil stockholding initiatives in Southeast Asia; fuel stockpiling and refinery capacity in Australia; gas storage targets. Investments by Gulf exporters in storage outside the Middle East.

In the ARC, we explore what would happen if these responses, often motivated by a desire to strengthen energy resilience, were to be translated into actionable policy proposals and then implemented. Activity levels and useful energy demand are similar to those in the CPS and the STEPS, but in the ARC, the implementation of measures that reflect these preferences means that global energy needs are met with a different combination of fuels and technologies.

The ARC is grounded in measures that are under consideration in different countries, but it is not intended as a prediction of future government actions, nor is it designed or optimised

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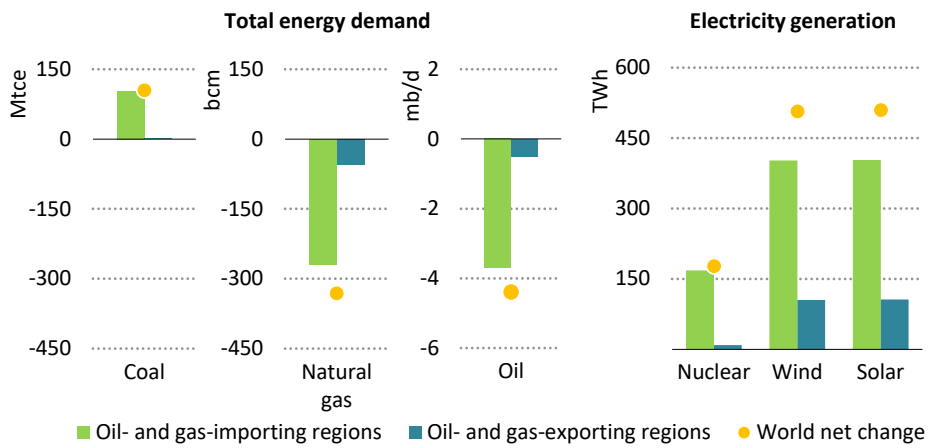
to achieve specific security-related objectives. It can, however, be seen as exploring an energy system in which decisions are shaped by concerns over resilience, diversification and trust, and in which there is less confidence than before in one of the usual pillars of energy security: a well-functioning system of international energy trade.

Given the uncertainty surrounding future geopolitical developments and the duration of market disruptions, actual policy responses could differ substantially from those represented in this chapter. That is why the ARC is presented as a case rather than a fully-fledged scenario. The chapter begins by examining how potential additional responses might affect the outlook for energy demand and power. We then review key questions and uncertainties for fuel supply and markets, including the possibility of measures to limit reliance on the Strait of Hormuz in the LHC.

5.2 Potential demand-side responses

5.2.1 Overview

Figure 5.1 ▷ Change in energy demand and electricity generation by source for oil- and gas-importing and -exporting regions in the ARC relative to the STEPS, 2035



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In the ARC, today's fuel importers lean towards energy resources available at home as well as diversification of international supply

Note: ARC = Additional Response Case; STEPS = Stated Policies Scenario; Mtce = million tonnes of coal equivalent; bcm = billion cubic metres; mb/d = million barrels per day; TWh = terawatt-hour.

The ARC does not present a uniform set of demand-side responses. Overall fuel demand is close to the levels projected in the STEPS over the next decade, with coal demand slightly higher and oil and natural gas use slightly lower, but there are contrasting trends between

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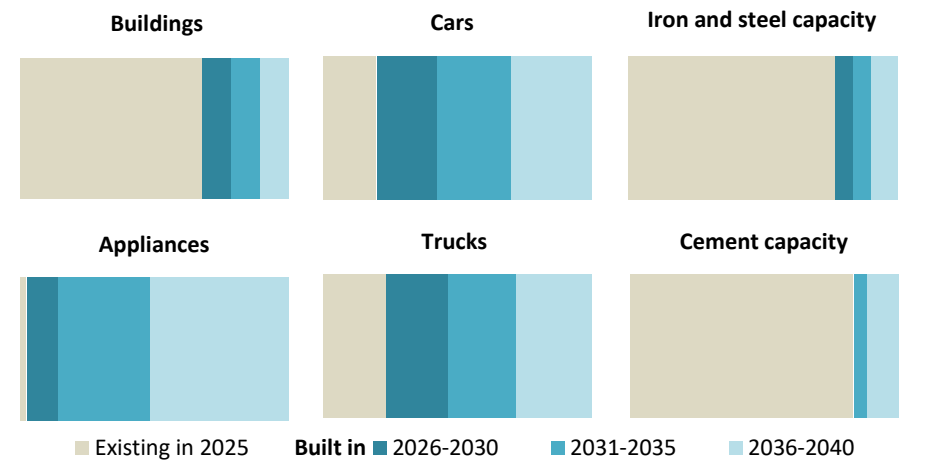
fuel-importing and exporting economies, and among countries within each of these groupings. Fuel-importing regions in aggregate invest more in resources available at home, which boosts renewables (such as wind and solar), nuclear and domestically available fuels, where their use is economically and geologically feasible. This reduces demand for imported oil and natural gas, and it is accompanied by enhanced efforts to avoid excessive dependence on single suppliers and routes for what they still need to import. The projections in exporting countries generally remain closer to those in the STEPS. With demand for their exports reduced, some exporting countries tend to use more of their production to meet domestic demand, although this is offset in aggregate by faster electrification and renewables deployment (Figure 5.1).

The way in which changes in policy feed through to changes in the capital stock varies across sectors and depends on sector-specific investment cycles and asset lifetimes. For example, most buildings and heavy industrial assets that will be in use in 2040 already exist today, but this is not the case for many vehicles and appliances (Figure 5.2). Retrofitting could accelerate changes in the buildings sector in particular, but it requires investment and is often disruptive.

Figure 5.2 ▷ Global stock by vintage for selected sectors in the ARC, 2040



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The speed at which policies can influence outcomes varies across the energy system because of distinctive investment cycles and lifetimes for different energy assets

5.2.2 End-use sectors

Transport

In oil-importing regions, the additional responses in the transport sector considered in the ARC reflect a push to diversify energy use and reduce dependence on oil, which at present

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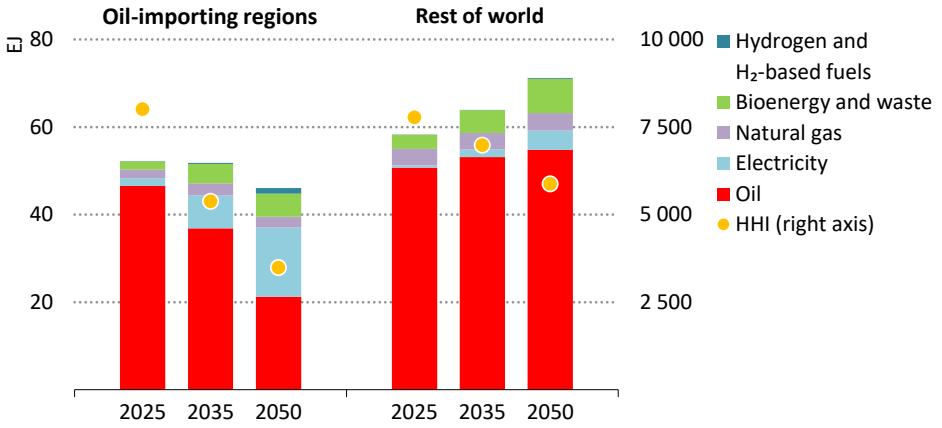
accounts for nearly 90% of transport energy demand. Approaches vary by country, but the main levers are electrification, fuel diversification and improved vehicle efficiency. In the ARC, transport oil demand from oil-importing regions declines by 5 million barrels per day (mb/d) by 2035 compared with today's level, with EVs accounting for around 80% of this drop and the remainder coming from efficiency gains and bioenergy. By 2050, electricity and bioenergy significantly reduce dependence on imported oil, particularly in road transport, and oil accounts for two-thirds of transport energy demand. As energy sources diversify, the transport fuel mix becomes less concentrated (Figure 5.3).

Figure 5.3 ▷ Energy demand in transport by fuel and by region in the ARC, 2025-2050



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Oil demand falls in oil-importing regions as the fuel mix for transport diversifies, while exporters remain more reliant on oil

Notes: EJ = exajoule; H_2 = hydrogen. Bunkers are excluded from the figures. HHI (Herfindahl-Hirschman Index) is calculated as the sum of squared fuel market shares of transport energy demand and is indicative of the fuel market share concentration. A value of 10 000 indicates a single-fuel market, while lower values indicate greater fuel diversity. In this analysis, HHI values below 2 500 indicate relatively low fuel concentration, typically reflecting 3-4 different fuels with sizeable market shares.

In oil-exporting regions, transport energy demand continues to grow, rising by around 10% by 2035 and over 20% by 2050, with the greatest increase taking place in the Middle East over the next decade. Oil consumption also increases, although its share of transport energy demand falls from 87% today to 77% by 2050 as bioenergy and other fuels capture a growing share of the transport energy mix, supported by expansion of ethanol blending in Brazil.

In aggregate, global road transport oil demand in the ARC falls from 44 mb/d today to 40 mb/d in 2035 and to less than 35 mb/d in 2050.

In the ARC, EV sales continue to grow in most of the regions, although adoption rates vary widely. The EV share of new car sales in China remained above 60% from April through

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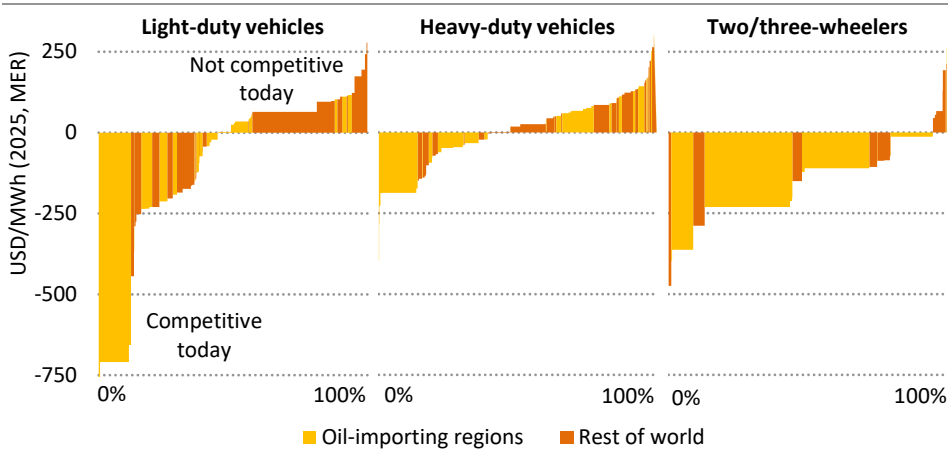
October 2026, and sales also grew strongly in Brazil, Australia, Korea, Europe and parts of Southeast Asia. Growing EV sales reflect a range of factors, including policy support, high gasoline prices, falling battery costs and growing availability of affordable models. Electric two/three-wheeler sales are also rising rapidly across several African, European and Southeast Asian countries. Many governments have announced measures to accelerate road electrification, including expanded EV tax incentives in Ireland and Spain, lower EV taxes in Viet Nam, preferential EV import treatment in Ethiopia and Kenya, support for electric public vehicle fleets in Chile and Sweden, and incentives for electric motorcycles in Indonesia. As a result, oil displacement from EVs is over 11 mb/d by 2035 in the ARC, more than six times the level in 2025.

Figure 5.4 ▷ Global electrification potential curve against electricity price premium in the road sector by region, 2025



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Oil-importing regions see stronger EV cost-competitiveness, while electric two/three-wheelers are already competitive across the majority of regions

Notes: MWh = megawatt-hour. The electrification potential curve displays the share of oil-based consumption that can be electrified at different electricity price premiums (computed against the local electricity end-use price of 2025 as a reference). A negative value on the vertical axis means that the end-use could be electrified cost-competitively, while a positive value indicates that the end-use is not competitive under today's conditions. The total cost of ownership is assessed at a regional level, accounting for local oil product and electricity prices at different charging conditions (home, public and fast-charging), vehicle capital and financing costs, maintenance costs, fuel economy, mileage, discount rates and resale value. The analysis assumes an eight-year ownership period for private vehicles and a ten-year period for commercial vehicles, with slightly faster depreciation for EVs than for internal combustion engine vehicles. Financial support and subsidies are not taken into account. Light-duty vehicles include passenger cars and light commercial vehicles. Heavy-duty vehicles include buses and medium and heavy freight trucks.

Although the global vehicle fleet grows by around 45% by 2050, rising EV adoption shifts transport energy demand from oil to electricity in the ARC, especially in places where EVs are cost-competitive (Figure 5.4). In most oil-importing regions, more than 60% of energy

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demand for light-duty vehicles is already cost-competitive to electrify, in part because these countries tend to impose relatively high taxes on fuels. Countries that are oil importers but apply relatively low taxes on fuel are still exposed to fuel price increases during oil supply crises, and these increases improve the cost-competitiveness of EVs. By contrast, only 30% of energy demand for light-duty vehicles could at present be electrified cost-competitively in regions with sizeable domestic oil resources; the figure is similar for heavy-duty transport. Payback periods to offset the upfront costs of EVs are therefore substantially shorter in oil-importing regions, averaging around five years for cars and ten years for heavy freight trucks, compared with ten years and 15 years, respectively, for oil exporters.

Electric two/three-wheelers are even more competitive than their electric light-duty vehicle counterparts due to their relatively small upfront cost premium; nearly all demand in oil importers, and around 75% in the rest of the world, is already cost-competitive to electrify. Most of the countries where electric two/three-wheelers remain uneconomic are oil-producing economies across Eurasia and the Middle East where low gasoline prices prevail.

Globally, aviation is the only transport mode in which oil demand continues to increase to 2050. The aviation sector's oil share reduces to just over 75% by 2050; however, the sector remains an increasingly important contributor to transport oil demand as other transport modes switch to electricity, biofuels and hydrogen-based fuels. Over-reliance on a single fuel is a growing concern for air transport, especially given rapid demand growth and the role of air transport in global supply chains, trade and economic activity. Sustainable aviation fuel provides an alternative to conventional jet fuel, but its high production cost means it currently accounts for less than 1% of the aviation fuel mix. Additional emphasis on the security of supply could help increase the use of sustainable aviation fuel and, by doing so, reduce its cost.

Shipping energy demand rises by over 15% by 2050 in the ARC as maritime activity expands. Oil dominates the fuel mix at present, but biofuels, methanol, liquefied natural gas (LNG), ammonia and hydrogen are playing an increasing role. Concerns about energy security and diversity may lead the take-up of these fuels to increase faster than it otherwise would.

Rail remains the least oil-intensive transport mode. Electricity continues to gain ground and is set to account for around 60% of global rail energy demand by 2050 in the ARC, further reducing oil dependence. High-speed rail is emerging as an alternative to short-haul aviation on suitable routes, avoiding some additional jet fuel demand (Box 5.1).

Box 5.1 ▻ High-speed rail in a fuel-insecure world

There could be some upside for high-speed rail in a world in which concerns grow about the security of jet fuel supply. For short- and medium-haul routes, which include journeys of less than 3 500 kilometres (km), high-speed rail (HSR) provides a possible alternative to travelling by air. HSR's potential as an alternative is greatest for shorter flights, in which take-off and landing account for a higher share of flight energy consumption.

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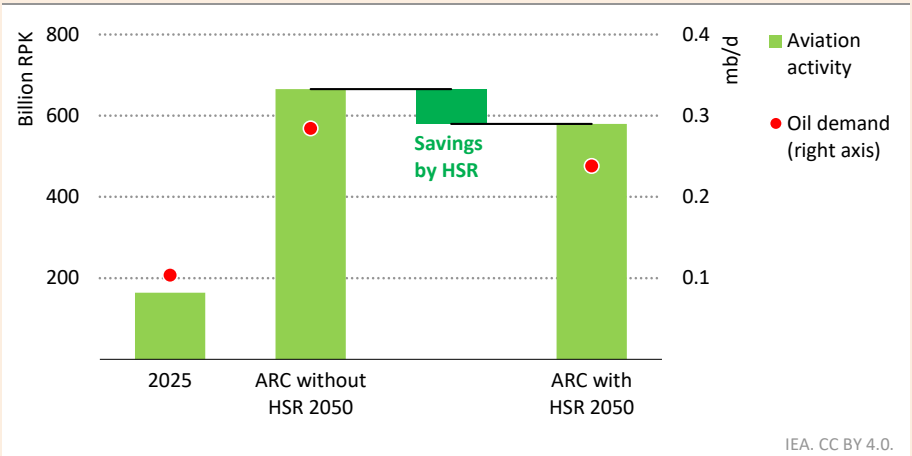
India is among the countries with scope to make more use of HSR in the longer term, and it already has plans for a substantial expansion of its HSR network in the coming decades. IEA analysis shows that announced HSR projects in India could save around 50 thousand barrels per day (kb/d) of aviation oil demand by 2050 (Figure 5.5). If all India's announced HSR projects were to be implemented, they would expand India's rail network by around 15 000 km by 2050, reducing aviation oil demand by more than 15% compared to a case without HSR deployment.

Other regions also see increased use of HSR in the ARC. For example, HSR activity grows by nearly 65% in Europe, and 70% in emerging market and developing economies excluding India, between today and 2050. Globally, HSR networks expand to almost 190 000 km by 2050, by which date they cover about 70% more distance than today. This could shift significant short- and medium-haul air travel to rail, reducing global jet fuel demand from the level it would otherwise reach.

Figure 5.5 ▷ Aviation activity and oil demand with and without HSR deployment in India in the ARC, 2025-2050



Compared to a no-HSR case, India's under-construction high-speed rail network could displace 50 kb/d of domestic aviation oil demand, over 15% of total demand, by 2050

Notes: RPK = revenue passenger kilometre; HSR = high-speed rail. RPK measures passenger traffic by multiplying the number of paying passengers by the distance travelled. It is the standard metric for air travel demand.

Buildings

The 2026 energy crisis has led to price shocks and supply shortages that have had a major impact on households, particularly those in countries in Asia that rely heavily on cooking fuels shipped through the Strait of Hormuz. This has prompted consideration of how to minimise the risks of shocks and shortages in the future. Several recent policy announcements by fuel-importing countries could help. The European Union's support for further electrification and

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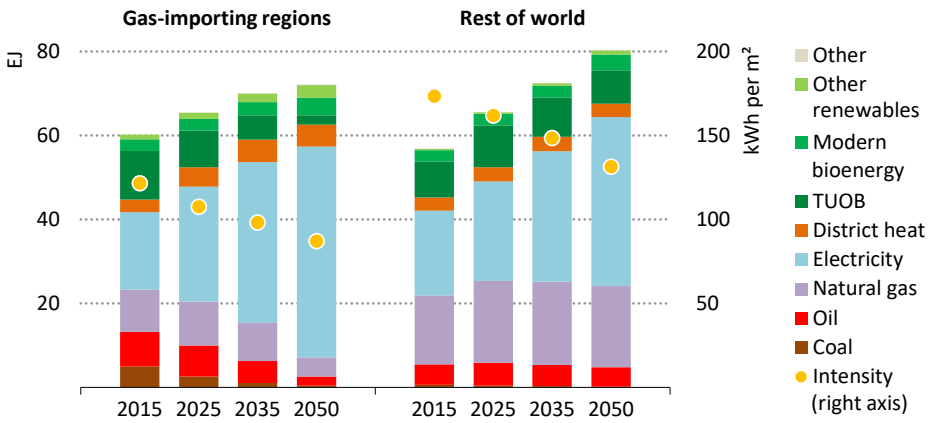
renewable energy deployment is clear from AccelerateEU and the EU Electrification Action Plan; and India is pursuing a diversification strategy that combines piped natural gas, electrification and renewable energy. Meanwhile, a number of fuel-exporting countries have published strategies and plans to accelerate economy-wide electrification.

Figure 5.6 ▷ Energy demand in buildings by fuel and by region in the ARC, 2015-2050



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In gas-importing regions, electrification accelerates, while efficiency improvements limit overall energy demand growth

Notes: kWh = kilowatt-hour; m^2 = square metre; TUOB = traditional use of biomass. Other renewables include solar thermal and geothermal. Other includes non-renewable waste and hydrogen. The buildings sector includes energy consumption for data centres and desalination.

The ARC explores the implications of stronger policy responses in gas-importing regions that are considering them. It shows gas-importing regions reducing annual oil and natural gas demand in the buildings sector by one-third and 15%, respectively, by 2035 as the average buildings sector electrification rate in these countries rises from 42% to 55% (Figure 5.6). The use of renewables and district heat also grows, with China leading the way on district heating. In gas-importing regions, despite a 17% increase in floorspace by 2035, buildings energy demand rises by only 7%. Space heating demand falls by nearly 10% over this period due to heat pump deployment and efficiency gains from building envelopes. In the rest of the world, floorspace increases by 20% by 2035 and buildings energy demand increases by 10% over the same period. Globally, the sector's electricity demand grows as the ownership and use of appliances and air conditioners rise; natural gas consumption remains broadly stable and oil demand declines by 20% by 2035.

At the global level, the buildings sector is already more electrified than the transport or industry sectors, with electricity accounting for 39% of its final energy consumption. However, much of this electricity demand is for end-uses that are almost entirely electric,

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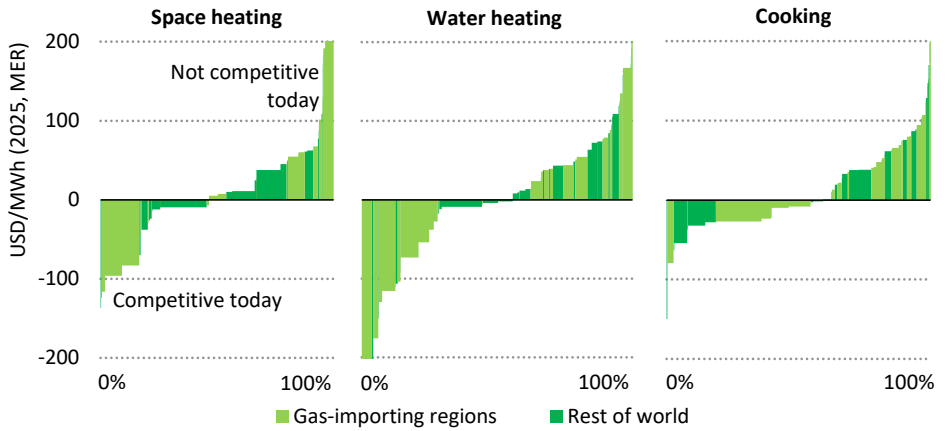
such as appliances, space cooling and data centres. For end-uses in which several fuels compete – such as space and water heating and cooking – the electrification rate is on average 15%. The remaining demand for these end-uses is met mainly by natural gas (which makes up just over 20% of the total energy demand in buildings), oil (around 10%) and the traditional use of biomass (around 15%).

Depending on the end-use, electric technologies can meet 45% to 60% of current fossil fuel-based consumption in buildings at costs comparable to or below alternatives (Figure 5.7). In aggregate, 50% of fossil fuel-based consumption can be electrified cost-competitively in buildings. An additional 30% of global consumption could be electrified cost-competitively if residential electricity prices were USD 50 per megawatt-hour (MWh) lower than today, although changes in fuel prices (including those resulting from taxation policy), equipment costs or policy design could materially alter the economics. If electricity prices increased by USD 50/MWh instead, the cost-competitive potential would drop to 20%.

Figure 5.7 ▷ Global electrification potential curve against electricity price premium in residential buildings by region, 2025



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Technologies require different electricity prices to break even, but cost-competitive potential exists across end-uses under today's conditions, notably in gas-importing regions

Notes: The electrification potential curve displays the share of fossil fuel-based consumption that can be electrified at different electricity price premiums (computed against the local electricity price for the sector as a reference). A negative premium means that electrification is cost-competitive. The levelised cost of technologies is assessed at a regional level based on local electricity and fossil fuel price, discount rate, investment cost and utilisation rate.

Gas-importing regions account for almost half of global demand for space heating and heat pump sales in these regions nearly triple by 2035 in the ARC. As a result, heat pumps account for 16% of the global heating equipment stock by 2035, up from around 10% today. Heat pumps are three to five times more efficient than gas boilers, delivering more heat than the

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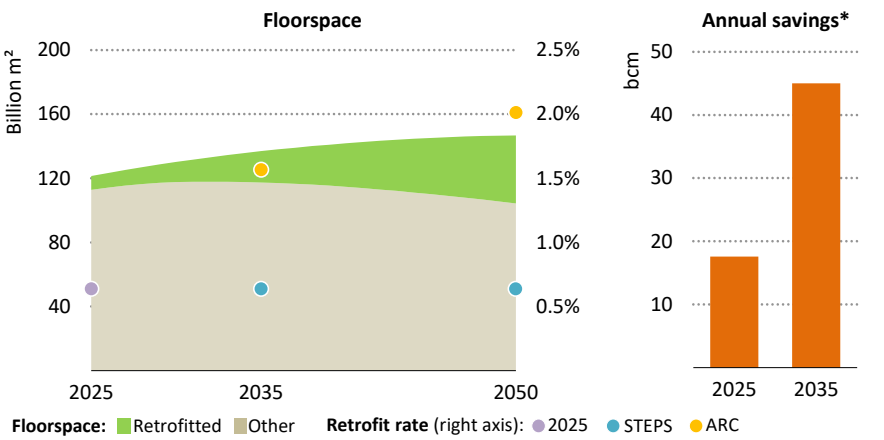
electricity they consume, so they bring substantial energy savings. The growing uptake of air conditioning in major heating markets creates an opportunity to accelerate the deployment of systems that can both heat and cool, known as reversible air conditioners or air-to-air heat pumps. These systems also save energy. By 2035, 20% to 45% of households in these markets install or renew an air conditioning system in the ARC. Increasing retrofit rates can also play an important role in improving energy efficiency (Box 5.2).

Box 5.2 ▻ Retrofit rates could get a boost from the 2026 energy crisis

In the aftermath of the 1970s oil shocks, mandatory building energy codes for new construction were introduced in some of the largest fuel-importing countries – the major heating markets in the global north. As a result, over half of the building stock in gas-importing heating markets in 2026 benefits from some energy efficiency measures incorporated during construction.

The mature building stock in these countries and its low turnover mean that most buildings that will be in use in 2040 have already been built. At the current low rate of retrofitting, it would take another 40 years for three-quarters of the current building stock in gas-importing heating markets to be covered by energy efficiency measures. Increasing the retrofit rate would shorten this timeline.

Figure 5.8 ▻ Retrofitted floorspace and natural gas savings from retrofits in gas-importing heating markets in the ARC, 2025-2050



Higher retrofit rates in the ARC moderate the impact of growing floorspace on space heating demand

* Annual natural gas savings represent avoided natural gas demand from all buildings retrofitted since 2000, compared to a case without any retrofits.

Note: Gas-importing heating markets = Chile, China, Europe, Japan, Korea.

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In the wake of the 2026 energy crisis, gas-importing heating markets, such as Japan, the Netherlands, Spain and the United Kingdom, have increased support for building envelope retrofits. In March 2026, the European Commission also announced a package of measures to boost private financing for energy-efficient retrofits. In the ARC, the building retrofit rate in gas-importing heating markets rises from 0.6% today to 1.6% by 2035, with annual gas savings from retrofits undertaken since 2000 increasing from 20 billion cubic metres (bcm) today to almost 50 bcm in 2035 (Figure 5.8).

Industry

The 2026 energy crisis has affected energy-intensive industries through disruptions to feedstock and material flows, higher energy prices and logistics constraints. The chemical sector relies heavily on Middle East supplies of naphtha, liquefied petroleum gas (LPG), ammonia and methanol, and it has been among the hardest hit, with economies in Asia experiencing the most severe impacts. In directly affected areas of the Middle East, around 12% of global ethylene capacity has been damaged, shut down or constrained by storage and export limitations, while methanol operating rates have been reduced because of gas supply constraints, power outages and export bottlenecks. Ammonia production in Iran and Qatar was severely disrupted, amplifying pressure on global fertiliser supply chains.

Industry and governments have responded by lowering operating rates, idling assets, sourcing alternative feedstocks, re-routing trade flows and prioritising domestic supply. Policy measures, such as the EU Fertiliser Action Plan announced in May 2026, have sought to increase fertiliser availability and domestic production. Producers in North America have benefited from access to domestic ethane-based feedstocks, although the limited quantities available to them have constrained their ability to offset losses elsewhere. In China, higher utilisation of coal-based methanol capacity has helped offset reduced supply from the Middle East, while some maintenance outages have been postponed in order to maximise domestic output. India has prioritised domestic fuel and fertiliser security by directing refineries to divert LPG away from petrochemical use and by allocating limited gas supplies to fertiliser plants. Japan and Korea, which have little domestic feedstock flexibility, have reduced ethylene operating rates, while some Asian buyers have sought alternative naphtha and LPG cargoes and adjusted trade routes where possible.

In the ARC, we explore the possibility and likely impact of additional policy responses where governments have indicated that they are considering them. These responses include support for electrification (notably in markets where electric technologies and applications are already competitive) and for energy efficiency improvements, together with greater use of domestic energy resources where they increase resilience (notably coal in parts of South Asia, and oil products in Argentina and Brazil). The scale of the current crisis also raises the prospect of a stronger and more widespread response from industry. In regions where electrification is already competitive, or close to becoming so, the experience of volatile fossil fuel costs could accelerate investment in electric technologies and associated efficiency improvements. Taking account of all this, the fossil fuel share in industrial demand in oil-

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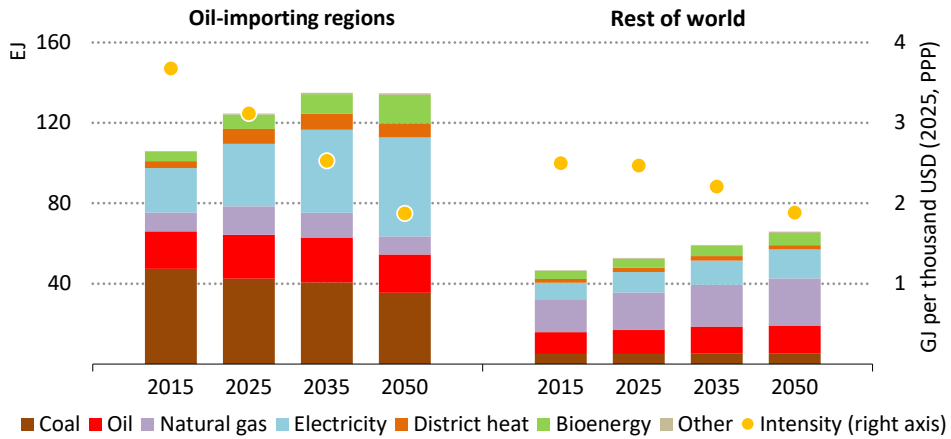
importing regions falls in the ARC from 63% in 2025 to 56% in 2035, while remaining essentially constant in other regions (Figure 5.9). Demand for electricity and bioenergy increases by more than 30% in oil-importing regions. Overall coal demand in industry falls back from its current level, but it is higher than in the STEPS, notably in China.

Figure 5.9 ▷ Energy demand in industry by fuel and by region in the ARC, 2015-2050



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Energy efficiency and electrification help to reduce fossil fuel use in industry; they reduce the fossil fuel share in industry in oil-importing regions from 63% in 2025 to 56% in 2035

Notes: GJ = gigajoule; PPP = purchasing power parity. Intensity is industrial energy demand per value added by industry. Other includes hydrogen, non-renewable waste, geothermal and solar thermal.

Around one-third of fossil fuel-based low- and medium-temperature heat demand in industry could be electrified cost-competitively today (Figure 5.10). All industrial sectors have some electrification potential, but most of it lies in non-energy-intensive industries and the chemical sector, which account for a large share of total demand for low- and medium-temperature heat (below 400 °C). Among countries with cost-competitive electrification opportunities, 90% are dependent on oil imports, highlighting the potential to strengthen energy security. However, electrification is still associated with an electricity price premium for most industrial heat applications, particularly in countries with significant domestic fossil fuel resources. Even where electrification is already cost-competitive, deployment is often constrained by non-cost barriers, including limited enabling infrastructure (for example, a low level of high-capacity grid connections), a lack of awareness of the availability and cost of electricity, and challenges in accessing finance. In the ARC, industry implements electrification where it is cost-effective and overcomes non-economic barriers. As a result, the industrial electrification rate in oil-importing regions rises by seven percentage points over the coming decade, compared with five percentage points in the previous decade.

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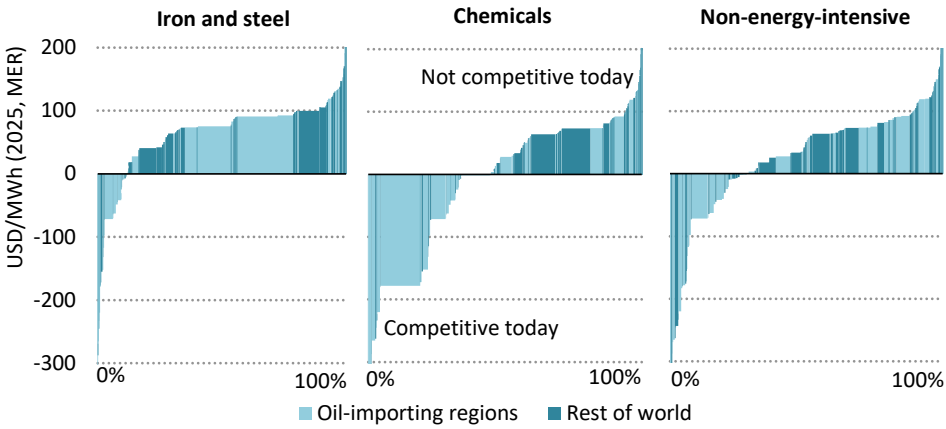
Figure 5.10 ▷ Global electrification potential curve against electricity price premium in industrial heat below 400 °C by region, 2025



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Most of the cost-competitive switch to electric technologies is in oil-importing regions; potential exists in all sectors, mostly in non-energy-intensive and chemical industries

Notes: Non-energy-intensive = non-energy-intensive industries. The electrification potential curve displays the share of fossil fuel-based consumption that can be electrified at different electricity price premiums (computed against the local electricity price for the sector as a reference). A negative premium means that electrification is cost-competitive. The levelised cost of technologies is assessed at a regional level based on local electricity and fossil fuel price, discount rate, investment cost and utilisation rate. Rest of world includes oil-exporting and oil trade-neutral countries.

5.3 Potential responses in the electricity sector

5.3.1 Demand

Electricity demand grows by around 11 500 terawatt-hours (TWh) over the coming decade in the ARC, an increase of 40% from today's levels. As in all the scenarios examined in this *Outlook*, electricity demand in the ARC grows faster than overall energy demand. Most of the increase comes from oil- or gas-importing regions, where electricity demand grows eight to nine times faster than overall energy demand, compared with a factor of around three elsewhere (Figure 5.11). This partly reflects the announcements or commitments by these countries to tackle vulnerabilities revealed by the 2026 energy crisis, together with a corresponding push to boost domestic sources of electricity generation, speed up the deployment of EVs and drive forward the electrification of heat in the industry and buildings sectors. The growth in annual electricity demand and changes in load profiles will shape the future power system.

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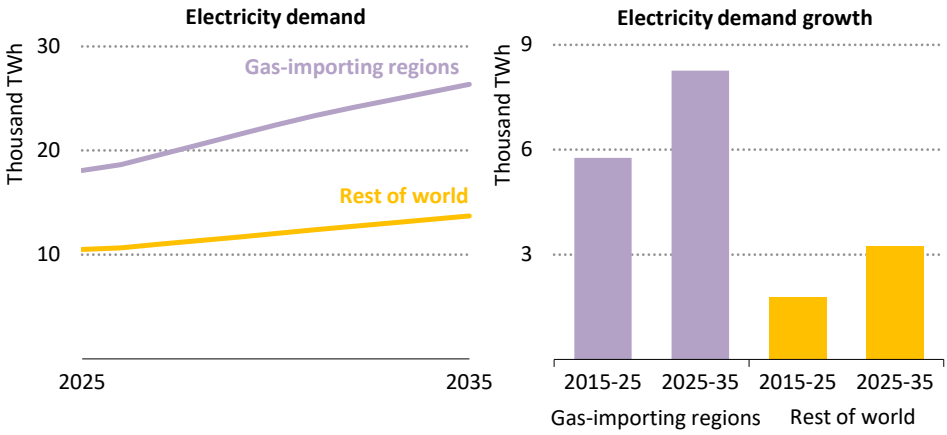
Figure 5.11 ▷ Electricity demand and electricity demand growth by region in the ARC, 2015-2035



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Faster electrification of industry and heating and more rapid adoption of EVs lead to faster electricity demand growth in gas-importing regions than the rest of the world

In industry, the share of electricity in gas-importing regions increases from less than 30% today to around 35% by 2035 in the ARC, while remaining broadly unchanged in the rest of the world. A similar shift occurs in transport, in which the share of electricity in oil- or gas-importing regions reaches around 15% by 2035, up from less than 5% today, while increasing at a moderate pace elsewhere. In the buildings sector, electrification advances rapidly in all regions, mostly driven by rising demand for appliances and cooling, but electricity demand growth in gas-importing regions is almost double that in the rest of the world. As a result, the share of electricity in buildings rises to 55% by 2035 in gas-importing regions, while remaining below 45% in the rest of the world (Figure 5.12).

Over the coming decade, electricity demand in gas-importing regions in the ARC increases by around 8 300 TWh (Figure 5.13). One-third of the overall increase is driven by the electrification of industrial energy use, particularly low- and medium-temperature heat applications. Electricity consumption in buildings contributes an even larger share, with rising demand for space cooling accounting for one-third of the increase in buildings. The transport sector also becomes an increasingly important source of electricity demand growth, accounting for around 20% of the total increase. By 2035, the share of EVs in the passenger car fleet in oil- or gas-importing regions rises from less than 10% today to nearly 40%, adding around 1 500 TWh of electricity demand from road transport in the ARC. Passenger cars remain the largest contributor, but accelerated electrification of medium and heavy freight trucks also plays a growing role, particularly in major importing economies, including China.

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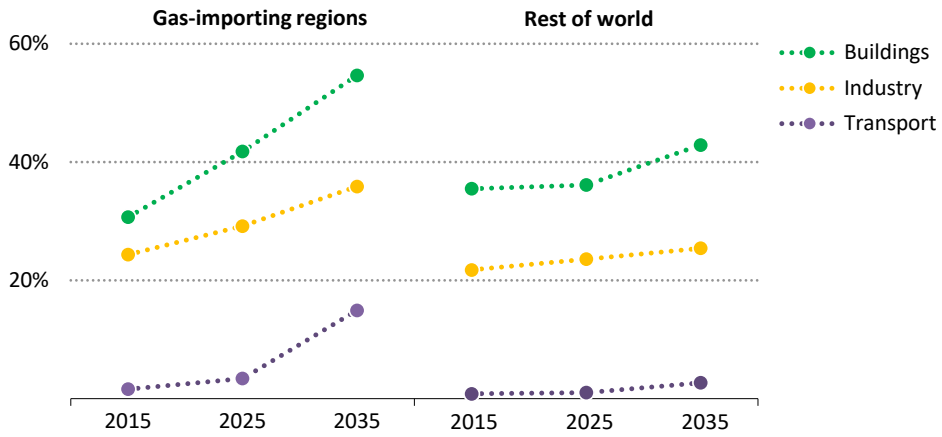
Figure 5.12 ▷ Electricity share by sector and region in the ARC, 2015-2035



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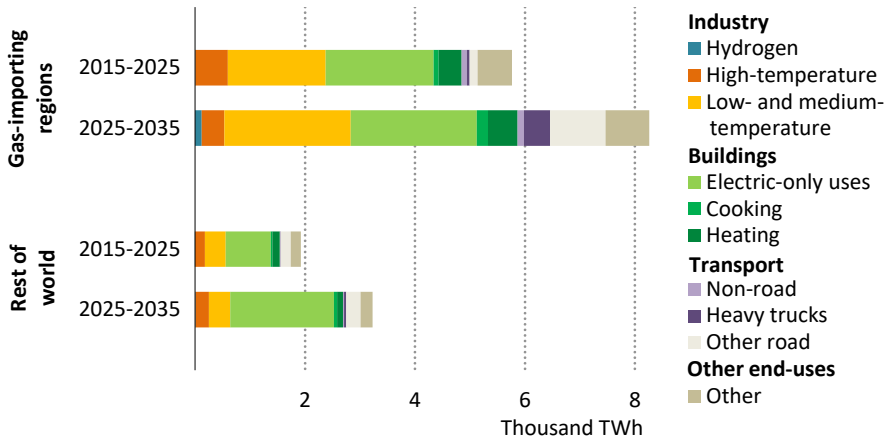
The share of electricity in all end-use sectors rises up to seven times as fast in gas importers as it does in the rest of the world over the coming decade

Figure 5.13 ▷ Electricity demand growth by selected end-uses and region in the ARC, 2015-2035



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Electricity demand growth in gas-importing regions is driven by industry, EVs, cooling and appliances; elsewhere it is driven by data centres, cooling and appliances

Notes: Hydrogen corresponds to the in-situ production of hydrogen on industrial sites. Other road includes passenger cars, two/three-wheelers, buses and light commercial vehicles. Low- and medium-temperature industry refers to non-energy-intensive industries, certain chemical products and the paper sector with heat demand primarily below 400 °C. High-temperature industry aggregates other energy-intensive industries.

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The outlook is markedly different in the rest of the world, where electricity demand increases by around 3 200 TWh over the coming decade in the ARC. Around two-thirds of this growth is concentrated in the buildings sector. One-third of the additional electricity demand in buildings comes from the rapid expansion of data centres, driven by increasing digitalisation and greater demand for cloud computing and artificial intelligence services. Space cooling also remains an important driver of electricity demand as rising incomes, urbanisation and higher temperatures lead more households to purchase and use air conditioning systems. However, electricity demand growth in other end-uses is modest compared with the much stronger electrification that takes place in gas-importing regions. These other end-uses include low- and medium-temperature heat applications, high-temperature industrial processes, passenger cars, and medium and heavy freight trucks. One important reason for this divergence is that some countries that are not oil or gas importers are in fact producers, and they use these domestic resources to meet part of their future energy demand. As a result, incentives to electrify end-use sectors are generally weaker.

5.3.2 Electricity generation

Table 5.2 ▷ Emerging power sector policy responses among fuel-importing economies following the 2026 energy crisis

Country / region	Specific policy signal	Renew-ables	Natural gas	Coal	Nuclear
Indonesia	Launch of 100 gigawatt solar photovoltaic (PV) and storage programme; lifting of coal output cap.	●	●	●	n.a.
Thailand	Draft power plan raises renewables and introduces nuclear, reducing reliance on gas; order to raise near-term coal output.	●	●	●	●
Other Southeast Asia	ASEAN reaffirms target of 45% renewables in regional power capacity.	●	●	●	n.a.
China	Order for higher near-term operations of coal power plants.	●	●	●	●
India	Reinforced objective to achieve energy independence target for 2047.	●	●	●	●
Japan	Near-term operation of inefficient coal plants extended.	●	●	●	●
Korea	Delay of coal plant retirements.	●	●	●	●
European Union	Short-term measures to increase coal availability, delayed closure of nuclear reactors and acceleration of renewables deployment.	●	●	●	●

● Favourable ● Unfavourable ● Neutral

The power sector has been exposed to the 2026 energy crisis mainly through the implications for LNG imports. In the ARC, electricity generation is central to the response from gas-importing economies: policy and market signals point to a strong effort to speed up electrification and meet the consequent increase in demand without as much reliance on

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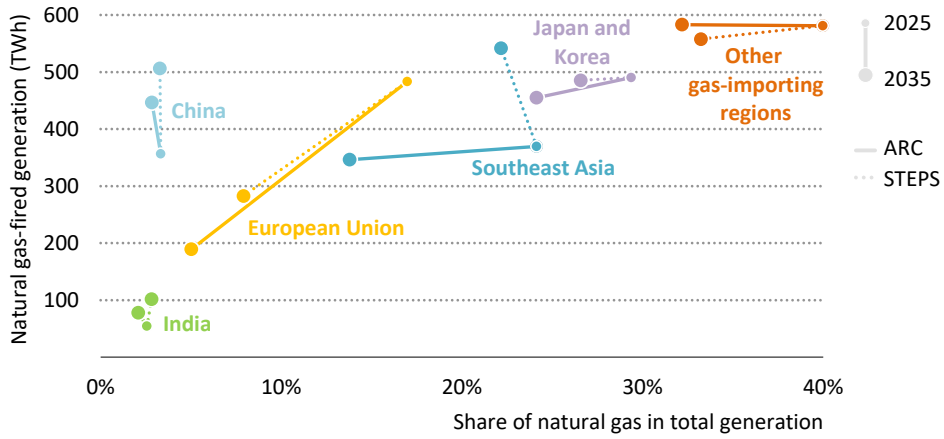
imported natural gas as in the past. Major LNG importers – including China, the European Union, India, Japan, Korea and Southeast Asia – have signalled measures that could limit gas use in power generation, chiefly through faster deployment of renewables, higher output from coal-fired plants in the near term and greater use of nuclear energy where applicable (Table 5.2). These signals have not all yet been translated into policy frameworks. The ARC explores what the implications would be if these publicly expressed policy proposals, strategies and responses were to be implemented and sustained.

The shift is clearest in the changing role of gas-fired electricity generation among gas importers. If their proposed responses were implemented, all gas-importing regions would reduce the share of gas in their electricity mix by 2035 (Figure 5.14). In the ARC, the largest adjustment takes place in the European Union, where gas-fired generation falls sharply and gas's share of the generation mix drops from 17% today to 5% by 2035. Japan, Korea, Southeast Asia and other gas-importing regions also see modest decreases in gas-fired generation, though the pace and scale of change differ across markets. In China and India, gas-fired generation still increases in absolute terms because electricity demand grows rapidly, but its share in total generation declines as other sources grow faster.

Figure 5.14 ▷ Natural gas-fired electricity generation and natural gas share in generation in gas importers in the STEPS and the ARC, 2025-2035



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Gas importers could put measures in place to reduce their reliance on gas-fired electricity generation in response to the 2026 energy crisis, a possibility reflected in the ARC

If the policy proposals and responses reflected in the ARC were implemented, gas-importing regions would see higher electricity demand than in the STEPS and would meet it mainly through additional low-emissions generation and higher output from existing dispatchable assets, including coal. In the ARC, solar PV and wind provide the largest part of the increase, in light of continued cost reductions, shorter development times and a preference for

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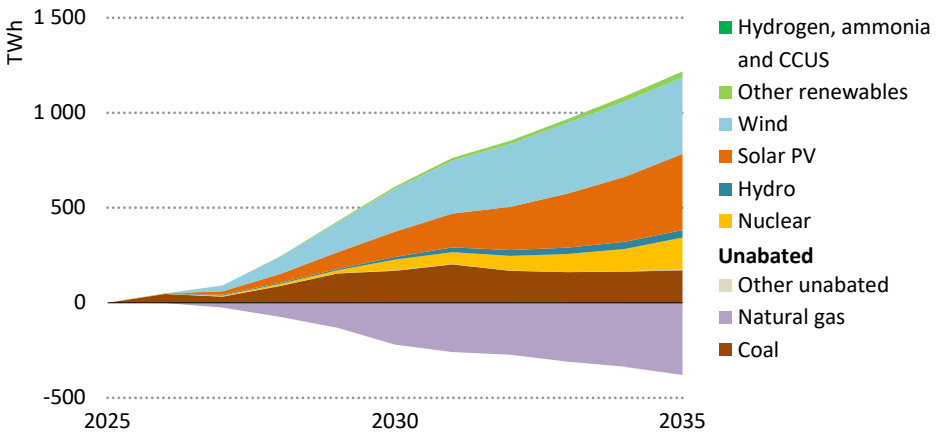
domestically available resources (Figure 5.15). Nuclear generation rises where proposals envisage new capacity, continued operation or greater output from existing fleets, while coal-fired generation rises from its level in the STEPS in markets where announced near-term measures seek to limit gas use. Among gas-importing regions, renewables, nuclear and coal combined produce around 1 200 TWh more electricity in 2035 than in the STEPS, while gas-fired generation is lower than in the STEPS.

Figure 5.15 ▷ Electricity generation by source in gas-importing regions in the ARC compared to the STEPS, 2025-2035



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In the Additional Response Case, faster electrification in gas importers would be met by more renewables, nuclear and coal than in the STEPS and less natural gas

Notes: CCUS = carbon capture, utilisation and storage; PV = photovoltaics. Other renewables include bioenergy and renewable waste, concentrating solar power, geothermal and marine. Other unabated includes oil and non-renewable waste.

At the regional level, the policy responses reflected in the ARC alter some trends in electricity generation. Solar PV and wind generation grows significantly more to 2035 than over the past decade in many regions, including China, India, Southeast Asia, the European Union, the Middle East, Central and South America, Africa, and Japan and Korea (Figure 5.16). Coal-fired generation follows a more complex path. It grew strongly over the past decade in China, India and Southeast Asia, but over the next ten years it declines from today's levels in China and growth also comes to a halt in India and Southeast Asia, despite near-term measures in some countries to raise coal-fired output. In the European Union, Japan and Korea, and North America, coal continues the decline already seen over the past decade. Nuclear power grows more strongly than in the previous decade in several countries, including China, India, Japan and Korea, or reverses previous declines, including in the European Union and the United States. The Middle East, North America and some other fuel-producing regions continue to increase gas-fired output using domestic resources, while natural gas use declines in many gas-importing regions.

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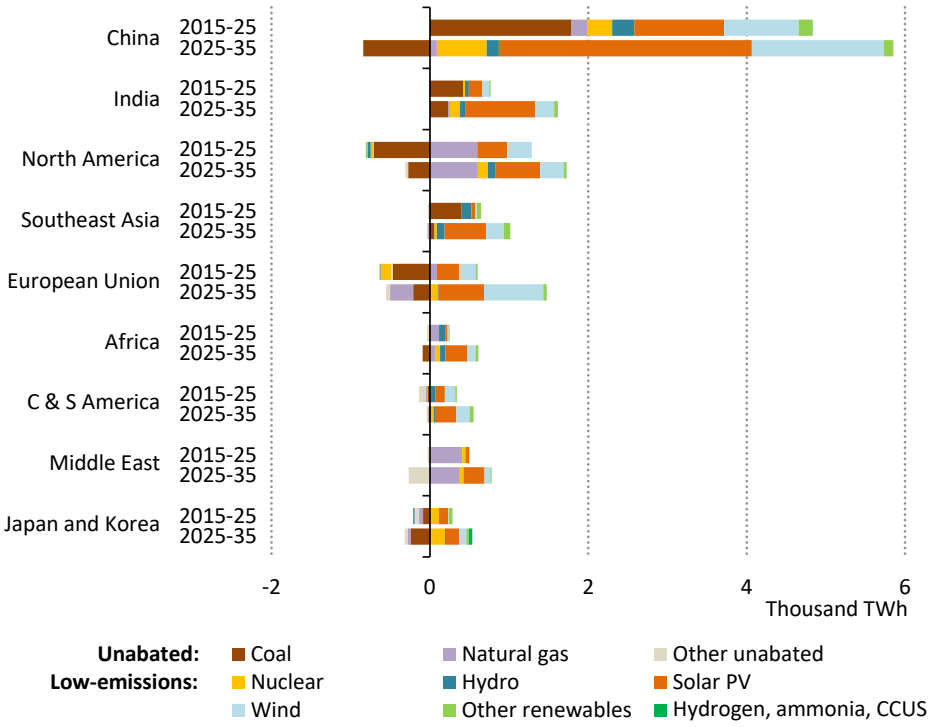
Figure 5.16 ▷ Change in electricity generation by region and source in the ARC, 2015-2035



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In the ARC, domestically available sources of power generation get a boost, providing upside for renewables as well as nuclear and coal compared with the STEPS

Notes: C & S America = Central and South America. Other renewables include bioenergy and renewable waste, concentrating solar power, geothermal and marine. Other unabated includes oil and non-renewable waste.

Implementation of all the policy proposals and country responses represented in the ARC, alongside broader market and technology trends, would reshape the global electricity mix. In the ARC, coal-fired power peaks before 2030 and then enters a sustained decline, but this decline is slightly less steep than in the STEPS. Natural gas plays a more stable role in absolute terms, but its share of generation declines from 22% in 2025 to 17% in 2035 and 12% in 2050. Nuclear power more than keeps pace with electricity demand growth, increasing its share from 9% today to 10% in 2035 and 12% in 2050. Renewables are the dominant source of growth, rising from around one-third of global electricity supply today to over half by 2035 and around two-thirds by 2050. In this case, the rapid rise of solar PV and wind also changes the operating needs of power systems and the nature of electricity security, increasing the importance of flexibility, grids and storage (see Chapter 7).

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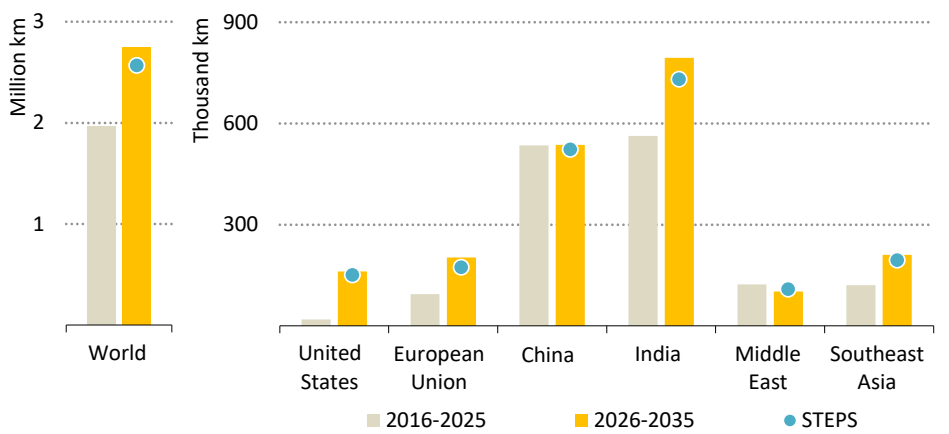
5.3.3 Grids

Faster electrification of end-uses and greater use of domestically available, low-emissions resources in the ARC lower dependence on imported fuels, but they also increase reliance on secure and adequately developed power systems. Electricity grids are the backbone of the energy system: if their expansion and modernisation lag behind demand growth and generation investment, there can be additional risks of increased grid congestion, connection delays, curtailment and deteriorating reliability.

In the ARC, global grid length increases by more than 30% from 2025 to 2035 to over 110 million km, and it increases again to 150 million km by 2050 (Figure 5.17). Emerging market and developing economies account for most of the increase, reflecting rapid electricity demand growth, industrialisation, urbanisation and renewables deployment. By 2035, their transmission networks expand by more than 2 million km, or over 50%, while their distribution networks grow by 20 million km, or 40%. Transmission is needed to connect resource-rich areas with demand centres, strengthen national systems and expand interconnections, while distribution networks must accommodate EVs, cooling, electric heating, new industrial loads, rooftop solar PV and batteries.

Figure 5.17 ▷ Average annual grid expansion by region in the ARC compared to the STEPS, 2016-2035



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Electricity networks expand in all regions to support evolving power systems

Note: km = kilometre.

China and India remain central to global grid expansion. In both countries, new transmission lines are developed to move electricity over long distances, while distribution systems need reinforcement to support urban growth, decentralised generation and transport electrification. The annual pace of grid expansion in India rises by 40% compared to the past decade: it adds 800 000 km of new lines per year through to 2035. The total national grid

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length in India is higher than in China today and remains so to 2035 with this growth. Other emerging market and developing economies see rapid grid growth, too. In Southeast Asia, robust demand growth and renewables deployment increase the need for stronger national networks, cross-border interconnections and more flexible system operation. In the Middle East, cooling demand, industrial diversification, electrification and renewables growth raise the importance of transmission reinforcement, regional interconnection and resilience, including in countries with substantial domestic fossil fuel resources.

Advanced economies also accelerate grid development. Expansion nearly triples by 2035 in the ARC compared to the past decade, with the European Union and United States accounting for two-thirds of this growth. Transmission networks in advanced economies expand over the next decade by 440 000 km, or 30%, and distribution networks by more than 5 million km, or over 15%. These economies also have most to do in replacing, repairing and reinforcing older systems, for example by adding interconnectors and high-voltage direct-current links to strengthen security by diversifying electricity supply, sharing reserves and balancing variable generation across wider areas.

Larger, more decentralised and more inverter-based power systems are complex to operate. Higher shares of solar PV, wind and batteries reduce the inertia and short-circuit strength traditionally supplied by synchronous generators, making system stability an explicit planning requirement. Power grids require adequate voltage regulation, reactive power control and grid-forming capabilities – provided by systems such as synchronous condensers or advanced static synchronous compensators – as well as adapted protection systems, black-start capability and more powerful operational tools. Digitalisation and automation become essential: sensors, high-speed communications, advanced controls and automated balancing improve visibility of power flows, help manage distributed resources and reduce the risk of local disturbances cascading into wider outages. These capabilities must be accompanied by greater resilience to physical, cyber and climate-related disruptions.

Delivery remains challenging. In all countries, achieving this scale and pace of grid expansion will depend on overcoming constraints in planning and permitting, financing, supply chains and the availability of skilled workers needed to design, build, operate and maintain evolving electricity networks. Supply chain pressures are mounting, with prices and delivery times for transformers nearly doubling in recent years, while raw material markets have tightened. Overcoming these challenges is critical to enabling more rapid electrification.

5.4 Potential responses in the fuels sector

The potential responses outlined above in end-use sectors and in power reflect a world of persistent worries about fuel security and lower confidence in international trade. In this section, we examine some of the potential implications and questions this raises for fuel suppliers, should the ARC materialise.

If the additional responses outlined in the ARC were to be fully implemented, global oil demand would decline from 102 mb/d in 2025 by 5% to 2035 and by 17% to 2050, whereas

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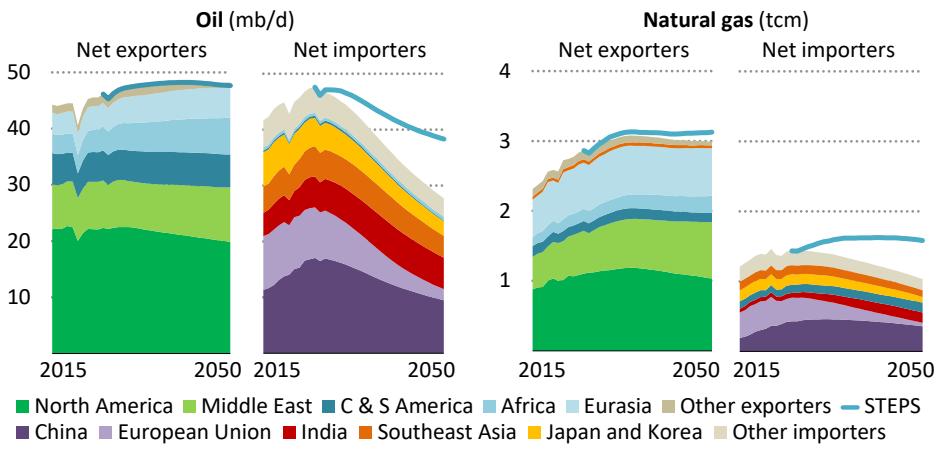
the STEPS sees demand declining marginally through to 2050. Almost all of the demand reductions in the ARC are among today's net oil importers, where consumption falls by 7 mb/d to 2035, while net oil exporter demand increases by around 1.4 mb/d, similar to trends in the STEPS. Global gas demand levels off in the ARC at 4 500 bcm in 2035, over 300 bcm below the level reached in the STEPS, and then gradually declines further to 2050. As with oil, the decline in global gas demand seen in the ARC is due to reduced demand from gas importers, which falls 6% (90 bcm) below 2025 levels by 2035 (Figure 5.18). On the other hand, global coal demand falls slightly more slowly in the ARC than in the STEPS, declining by just under 13% to 2035 and by 40% to 2050.

Figure 5.18 ▷ Oil and gas demand by region in the ARC compared to the STEPS, 2015-2050



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Global oil demand in the ARC falls to 97 mb/d in 2035 and 85 mb/d in 2050 as several countries rein in consumption, although demand in oil-producing regions is more resilient

Notes: tcm = trillion cubic metres. Excludes international bunkers.

These outcomes raise questions about how demand for imported fuels might evolve if Gulf supplies are not reliably available or are subject to a continued material risk of disruption, or if importing countries are hesitant to build out new import infrastructure, particularly in the case of LNG. Lower demand for imported fuels could also bring lower prices, which could in turn induce rebound effects, or reconfigure global trade and investment in different ways, depending on how importers prioritise security and cost.

There are many uncertainties to contend with. It is unclear how long the disruption to oil and gas supply out of the Middle East will last, or to what degree countries will wish to reduce reliance on the Strait of Hormuz. That is why, alongside the presentation of the ARC projections, this section explores multiple uncertainties which could affect the outlook for fuel markets.

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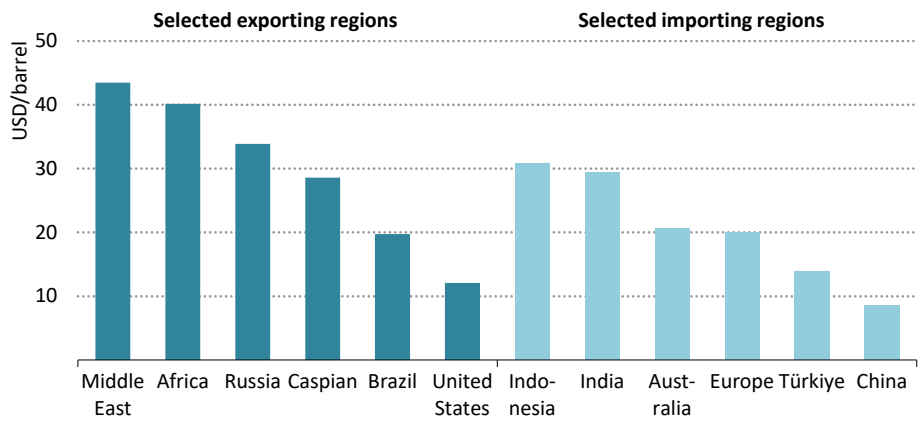
5.4.1 How much scope is there to expand domestic supply in oil- and gas-importing regions?

In the ARC, importing countries seek to maximise domestic oil and gas supplies to reduce dependence on imported fuels and exposure to global chokepoints such as the Strait of Hormuz (discussed below). However, encouraging domestic production above the levels of the STEPS is challenging, given that equilibrium oil prices in the ARC are lower because of lower demand. To the extent that resources are available in net-importing countries, they tend to be higher cost and, in some cases, require significant investment in new infrastructure.

A key lever for importers looking to encourage additional production would be to ease the fiscal terms for upstream investment in both exploration and production. The government take of the value created by upstream developments varies widely across jurisdictions and project types, but it is substantial everywhere. For example, between 2021 and 2025, governments in established producers in the Middle East and North Africa captured around 70% of net cash flows from oil sales on average. In importing countries, government tax take per barrel is generally lower, since oil and gas development often involves higher costs and lower potential returns for companies than in exporting countries, meaning that countries must offer more attractive terms to secure inward investment (Figure 5.19).

Figure 5.19 ▷ Average government tax take from oil production in selected net-exporting and net-importing regions, 2021-2025



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Different regulatory regimes, resources and revenue lead to large variations in government income from oil; the tax take in importing regions is generally lower than for exporters

Source: IEA analysis based on data from Rystad Energy (2026).

Several oil- and gas-importing regions have already enacted favourable legislation in recent years to stimulate domestic production. For example, India's Hydrocarbon Exploration and Licensing Policy introduced seven-year royalty holidays for deepwater and ultra-deepwater

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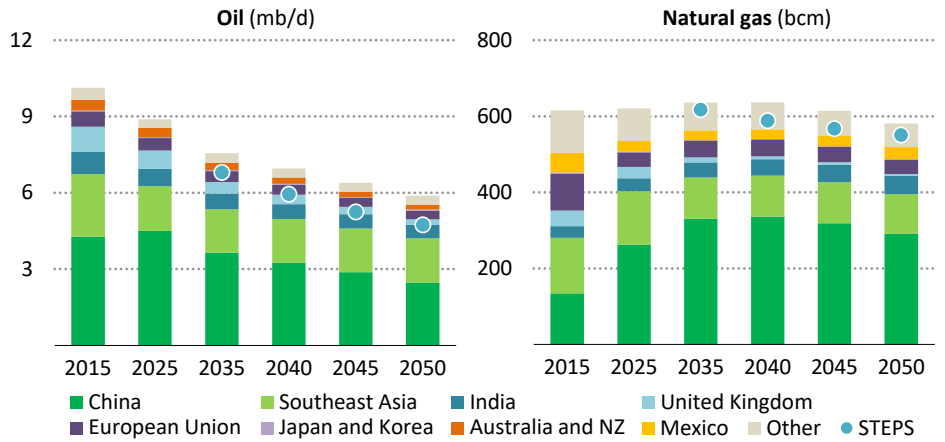
projects, open-acreage licensing and greater pricing flexibility, while subsequent reforms removed standard government revenue-sharing requirements in less-explored basins. Türkiye's Petroleum Law provides tax and customs incentives for exploration investment, while Indonesia has used tax relief and more flexible production-sharing arrangements to improve the economics of upstream projects.

While targeted fiscal incentives, particularly for higher-cost resources, could encourage production above STEPS levels, the upside potential is relatively modest. In the ARC, upstream incentives introduced in all net oil-importing regions raise production in 2035 by around 0.8 mb/d (10%) compared with the STEPS. Most net-importing regions with domestic production have a mature resource base, meaning there are limited opportunities to increase production significantly, even with more attractive exploration and development incentives. Furthermore, new exploration licences are unlikely to have a material impact on production levels to 2035, given the lead times for discovering and developing new projects: on average, it takes just under 20 years from when an exploration licence is first awarded until production begins (IEA, 2025). In 2050, production in net-importing regions is around 1 mb/d higher in the ARC than in the STEPS; even with this boost, overall production in net-importing regions still declines by 2050 in the ARC (Figure 5.20).

Figure 5.20 ▷ Oil and natural gas production in net-importing regions in the ARC compared to the STEPS, 2015-2050



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Lower upstream taxes raise importer production in the ARC by 0.8 mb/d relative to the STEPS in 2035, though output still falls; for gas, importer production is about 20 bcm higher

Note: NZ = New Zealand.

In the ARC, efforts to reduce demand and boost domestic production in importing countries mean that global oil trade in 2035 is 12% (5 mb/d) lower than in the STEPS and global gas trade is 30% (325 bcm) lower. This has significant implications for exporters, but the effects are uneven given parallel efforts by importers to secure reliable supplies and maintain or

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improve the diversity of their imports. These efforts encourage production from several importing countries which see higher levels of production than in the STEPS. Some exporters in Africa and Central and South America also see oil or gas production above STEPS levels in 2035. These developments reduce the call on production from Saudi Arabia, the largest producer of the Organization of the Petroleum Exporting Countries, while Russian oil and gas production is around 10% lower in the ARC compared to the STEPS.

5.4.2 To what extent can oil supply become less dependent on the Strait of Hormuz?

In the STEPS, oil flows through the Strait of Hormuz recover to 20 mb/d by 2035 (similar to 2025 levels), while LNG flows rise to almost 200 bcm in 2035 (up from about 110 bcm in 2025). This dependence represents a significant structural vulnerability for oil and gas markets. An open question – brought into sharp focus by the 2026 Middle East conflict and resulting energy crisis – is to what extent this dependence could be cut over the next ten years. Using results from the STEPS, we explore here the main options available to countries in the Low Hormuz Case (LHC). These options include expanding bypass routes, boosting oil and gas production outside the Strait, and reducing demand. Additional stockholding policies and storage infrastructure outside the Strait could also enhance resilience by providing important buffers in the case of disruption (see Chapter 7), but they do not offer structural solutions to reducing dependence.

Bypass routes

Around 8 mb/d of pipeline capacity that bypasses the Strait of Hormuz is currently available in the Persian Gulf to serve export markets. These pipelines carried around 2.0 mb/d of exports on average in 2025 and ramped up to a peak of 6.8 mb/d during the 2026 energy crisis.[2] Capacity under construction in the United Arab Emirates (UAE) is set to expand bypass routes by 1.8 mb/d. A further 5 mb/d of larger-scale export projects have been proposed, including an expansion of the Petroline linking Saudi Arabia's Gulf production to the Red Sea, which is currently in front-end engineering design, but these remain subject to approval.

In the STEPS, under-construction projects are assumed to be completed, and bypass pipelines operate at utilisation rates similar to pre-crisis levels in 2025. This means that around 3 mb/d of oil flows bypass the Strait of Hormuz in 2035 in the STEPS. If all existing, under-construction and proposed bypass routes (except the Duqm pipeline), as well as export infrastructure at Yanbu, were to be developed and used to their available export capacity, this would increase bypass flows in 2035 to around 14.5 mb/d. As a result, flows through the Strait would reduce from 20 mb/d in 2035 in the STEPS to around 8 mb/d.

This would allow most exports from Saudi Arabia and the United Arab Emirates, along with 2 mb/d, or over 60%, of Iraq's exports, to avoid the Strait, but the waterway would remain a

[2] Exports were lower than nameplate capacity due to domestic demand, export terminal and upstream production constraints, and operational limitations.

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bottleneck for Bahrain, Kuwait and Qatar (Figure 5.21). The cost of developing these additional bypass capacities would be around USD 40 billion.

Table 5.3 ▷ Crude oil pipeline capacity and flows bypassing the Strait of Hormuz in the STEPS and the LHC, 2025-2035

	Name	Full route	Capacity (mb/d)		Bypass flows (mb/d)			
			Nameplate	Export	2025	2026 peak	2035 STEPS	2035 LHC
	Operational							
1	Abu Dhabi Crude Oil Pipeline (ADCOP)	Habshan-Fujairah	1.5	1.8	1.0	1.8	1.0	1.8
2	Petroline (Saudi Arabia East-West)	Abqaiq-Yanbu	5.3*	5.0	0.8	4.6	0.8	5.0
3	Iraq-Türkiye Crude Pipeline (ITP)	Kirkuk-Ceyhan	1.6	0.7	0.2	0.4	0.2	0.7
4	Goreh-Jask Crude Oil Pipeline	Goreh-Jask	1	0.3	0	0	0	0.3
	Total		**9.4**	**7.8**	**2.0**	**6.8**	**2.0**	**7.8**
	Under construction							
5	Abu Dhabi pipeline (West-East 1)	Habshan-Fujairah	1.8	1.8			1.0	1.8
	Total		**1.8**	**1.8**			**1.0**	**1.8**
	Proposed							
6	Petroline expansion	Abqaiq-Yanbu	3.0	3.0				3.0
7	Haditha-Baniyas oil pipeline**	Basra-Baniyas	1.0	1.0				1.0
8	Haditha-Fishkhabur oil pipeline**	Basra-Ceyhan	1.0	1.0				1.0
9	Abqaiq-Duqm oil pipeline	Abqaiq-Duqm	n.a.	n.a.				
	Total		**5.0**	**5.0**				**5.0**

*5.0 mb/d capacity for crude oil and 0.3 mb/d for natural gas liquids (NGLs).

**These pipelines connect to the Basra-Haditha oil pipeline, which is currently under construction. The Haditha-Fishkhabur pipeline also connects to the existing ITP (3).

Notes: LHC = Low Hormuz Case. Available export capacity reflects maximum historical export flows and may differ from nameplate capacity. For 2026 peak flows, only the period from January to October is considered.

While bypass routes reduce reliance on the Strait of Hormuz, they remain vulnerable to operational disruptions and security risks. In addition, bypass routes going via the Red Sea typically require transit through the Bab el-Mandeb Strait, between Yemen in the Arabian Peninsula and Djibouti and Eritrea in Africa, where attacks on commercial shipping have taken place during 2026. Were this route to be interrupted, the only exit from the Red Sea would be via the Suez Canal or the Suez-Mediterranean pipeline, which has a capacity of around 2.5 mb/d. Oil destined for Asian markets would then have to travel through the Mediterranean and around Africa.

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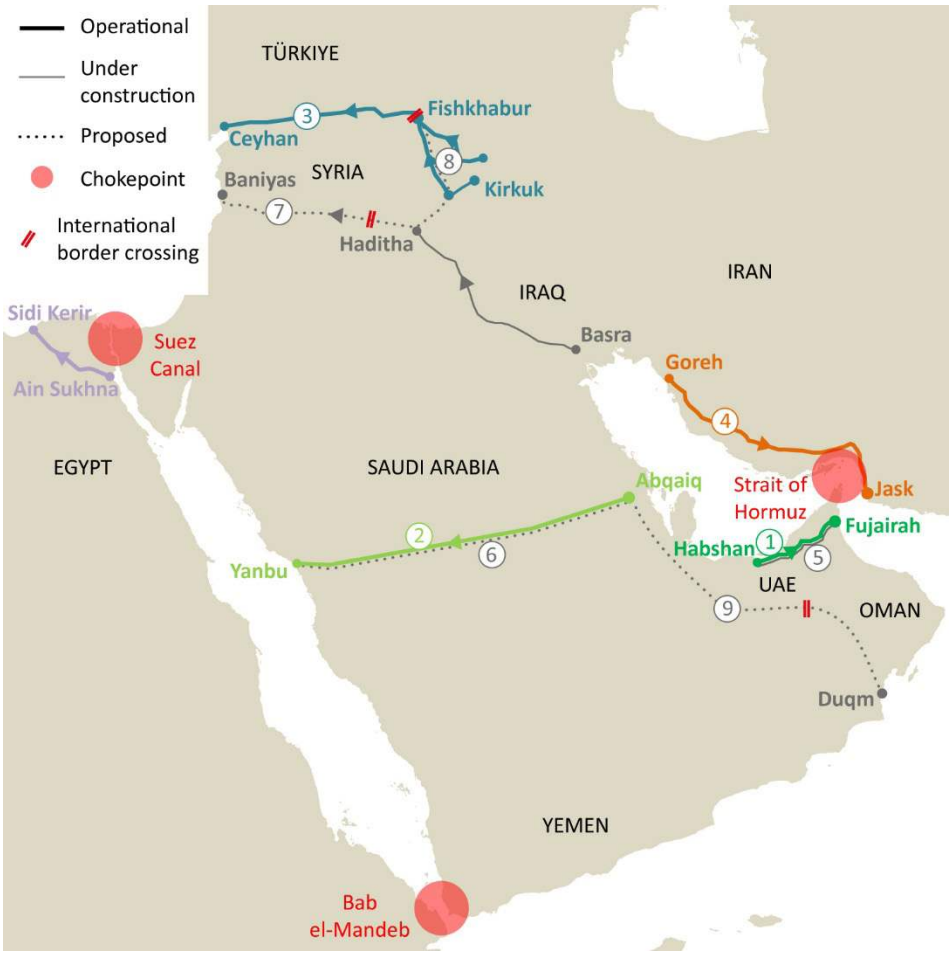
Figure 5.21 ▷ Existing and proposed infrastructure bypassing the Strait of Hormuz



Around 8 mb/d of capacity can currently bypass the Strait of Hormuz; a further 2 mb/d of projects are under construction, and another 5 mb/d have been proposed

Note: Numbers next to pipelines correspond to their order in Table 5.3.

Supply increases and demand reductions

In the LHC, oil demand among net importers is 4 mb/d lower in 2035 than in the STEPS, and they increase domestic production by around 0.7 mb/d relative to the STEPS. If exporters outside the Middle East were to see an opportunity to sell oil to importing countries that wished to reduce their dependence on the Strait of Hormuz, and if buyers and sellers were to find a way to cover any relevant differentials versus Middle East barrels, for instance higher transport costs, this could bring a further 1.9 mb/d to market by 2035 in the LHC.

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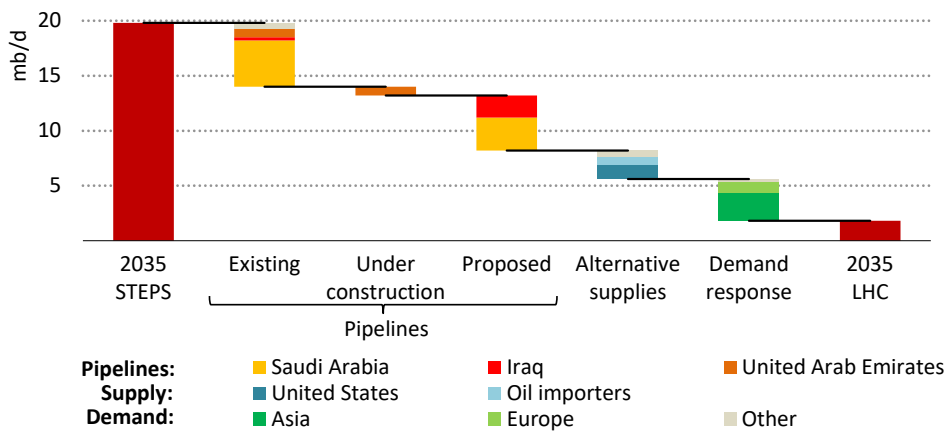
More than 1 mb/d of this 2.6 mb/d would come from the United States, where upstream production can respond relatively rapidly to opportunities to increase drilling. Countries that could closely match the quality specifications of crude shipped via the Strait of Hormuz would also be at an advantage. Russian Urals oil is well placed on this front, but Russia's supply growth beyond STEPS levels is capped by sanctions and difficulties in developing fields in more remote and technically challenging environments (see Chapter 8). Canada, Venezuela and Mexico are also well placed to replace heavier crude grades.

Average annual investment in oil supply of over USD 200 billion would be needed between 2025 and 2035 to achieve this increase in supply, which would be 5% more than the equivalent investment in the STEPS. Around 80% would be spent on oil and gas exploration and development, with the remainder going towards developing additional pipeline exports and expanding or retrofitting refining capacity to adapt to different qualities of crude.

The reductions in demand and increases in supply in the LHC could arise if transit through the Strait of Hormuz remains constrained or unreliable, and if this were to galvanise importers and exporters into taking concerted steps to avoid the waterway. Provided that all the bypass capacity, demand reductions and production increases set out in this analysis materialise, the volumes of oil that need to flow through the Strait in 2035 to meet global demand could drop from the 20 mb/d seen in the STEPS to around 2 mb/d seen in the LHC (Figure 5.22). It is therefore possible for the world's oil supply to become dramatically less dependent on the Strait of Hormuz. It is much more challenging, however, to envisage reduced dependence on the Middle East as a producing and exporting region; in any case, the Middle East remains of pivotal strategic importance to global oil supply.

Figure 5.22 ▷ Differences in oil flows through the Strait of Hormuz in the STEPS and the LHC, 2035



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By developing bypass routes, lowering demand and boosting production outside the Middle East, flows through the Strait of Hormuz in 2035 could be cut from 20 mb/d to 2 mb/d

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5.4.3 Can oil product importers become self-sufficient?

From a security perspective, oil importers usually favour importing crude oil and refining it domestically rather than importing finished oil products. This is because crude oil is traded in large and liquid international markets, while oil products are traded in markets that tend to be smaller and more regionalised. Oil products are also often more expensive to store over long periods than crude oil, particularly where they have tighter quality specifications or safety requirements. Domestic refining capacity can therefore provide a buffer against disruptions in oil product supply.

Yet maintaining a large domestic refining business in importing countries is not always an option. The security benefits need to be weighed against technical and economic considerations: refineries need to have the right configurations to handle diverse crude oil feedstocks and to produce products to required specification, and domestic refineries could find profitability very challenging if either changes. Keeping a high level of spare refining capacity, or building or upgrading refineries to be more flexible, can also entail high additional costs.

These trade-offs are not limited to oil-importing regions. Oil exporters can also be net importers of oil products where domestic refining capacity is insufficient to meet their needs. This can make economic sense, especially where competitively priced product supplies are available, but it increases their exposure to international price shocks and supply disruptions.

Figure 5.23 ▷ Net crude oil and oil product trade for selected regions in the STEPS and the ARC, 2025-2035



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Increased domestic refining among importers results in lower oil product trade in the ARC than in the STEPS; this boosts crude imports, but the effect is offset by lower demand

Notes: Crude oil includes crude and condensate. Products include refined products, fractionated products and other fossil-derived liquid fuels.

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Around 30 mb/d of oil products were traded globally in 2025, with Southeast Asia (3.2 mb/d of gross imports), Central and South America (2.7 mb/d), and sub-Saharan Africa (2.3 mb/d) among the most import-dependent destinations (Figure 5.23). These three regions see increases in oil demand in the STEPS through to 2050, which in principle creates an economic rationale for mobilising capital to modernise or increase existing refining capacity.

Southeast Asia sees refinery throughput grow by 0.8 mb/d to 2035 in the STEPS, and net oil product imports stay broadly flat at around 2 mb/d. The region's import needs could be reduced by more than half by adding around 0.5 mb/d of new refining capacity tailored to produce road transport fuels, leaving LPG as the main imported product in the ARC.

Central and South American countries see net oil product imports rise by 0.1 mb/d to almost 2 mb/d by 2035 in the STEPS. Greater utilisation of existing refineries, combined with around 0.3 mb/d of new refining capacity, could cut net imports by 30% by 2035 in the ARC compared to the STEPS. However, less than 150 kb/d of new capacity has been built in the region in the past decade, offset by 500 kb/d in closures, and the US Gulf Coast refineries provide a large and competitive source of nearby supply, making such an expansion a significant departure from recent trends.

Sub-Saharan Africa is in the midst of huge refining expansions, with capacity set to rise from 1.8 mb/d to 3.5 mb/d by 2035, in large part as a result of the 0.7 mb/d Dangote expansion in Nigeria and new capacity in Kenya. Consequently, product imports contract by 0.6 mb/d by 2035 in the STEPS. Further demand reductions play only a limited role in the ARC, given the region's position as a net oil exporter. Adding 0.5 mb/d of extra refining capacity and increasing average utilisation rates to around 75% (up from 65% in the STEPS) could cut net product imports in 2035 by around half from STEPS levels, mainly for gasoline and diesel. Even then, around 0.3 mb/d of LPG imports would remain (less than 5% lower than the STEPS), reflecting the difficulty of fully eliminating imports given refinery product slates and the availability of low-cost LPG from international markets.

For importers with falling oil demand in the ARC, a key dilemma is whether and how to invest in new or maintain existing refining capabilities. Regions accounting for 60 mb/d of refining capacity today, including China and the European Union, are set to see declining regional oil demand in the STEPS, which has challenging implications for the economics of the refining sector. Prolonged periods of low or negative refining margins in the European Union prior to 2022 led to widespread refinery closures as plants struggled to compete with newer and more efficient facilities in Asia and the Middle East. The least competitive refineries around the world are similarly likely to struggle if regional demand for oil and oil products falls in the years ahead. If refining capacity falls faster than demand, import dependence could increase, particularly for products with more resilient demand, such as jet fuel and naphtha. In the ARC, planned refinery closures are delayed for energy security reasons, but maintaining surplus refining capacity has to be balanced against the cost of the support required for assets that could be unprofitable under normal market conditions.

In total, we estimate that expanding refining capacity closer to demand centres, delaying planned refinery closures and retrofitting capacity to better match local demand patterns

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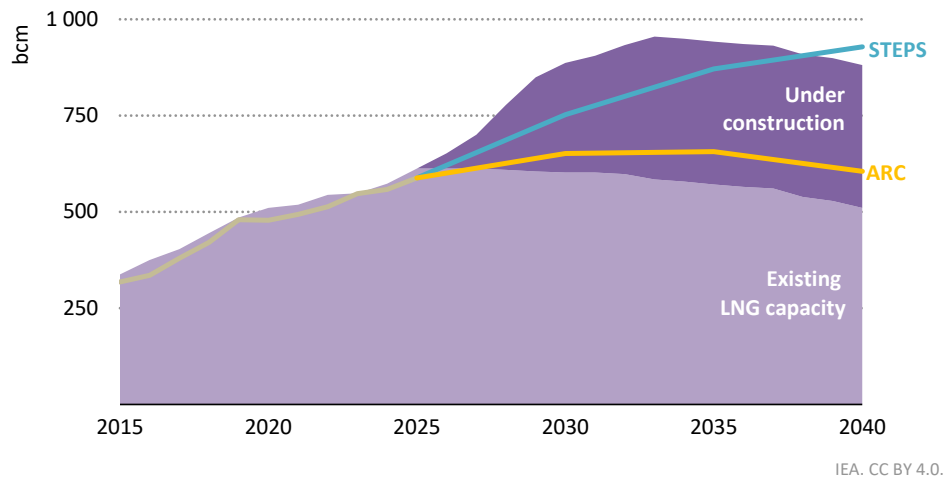
could reduce gross oil product imports in 2035 from around 35 mb/d in the STEPS to less than 30 mb/d in the ARC. Achieving this would require 5 mb/d of new refining capacity in net-oil-product-importing regions, compared with 3 mb/d in the STEPS, as well as upgrades and modifications to around 8 mb/d of existing refining capacity. This would raise cumulative global refinery investment in product-importing countries to USD 400 billion by 2035, 80% higher than in the STEPS, and translate into a USD 3-4 per barrel increase in costs for consumers.

5.4.4 How much surplus LNG should we expect to see?

Around 400 bcm of new liquefaction capacity is due to come online between 2025 and 2035, based on under-construction projects as of October 2026. Taking into account anticipated retirements of existing plants and adjusting availability for normal maintenance and ongoing outages, global LNG export capacity is set to grow from around 610 bcm per year in 2025 to around 940 bcm per year by 2035. Most of this new capacity is due online by 2030, and for the market to absorb all of this new supply over that period, annual average growth in LNG demand would need to rise to nearly 9% per year, double the average between 2020 and 2025. This is the outcome in the CPS, underpinned by continued LNG demand growth in China, Europe, India and Southeast Asia, among others. In the STEPS, announced new policies reduce demand growth from the level seen in the CPS. As a result, the LNG balance is much looser in the years ahead, and there is a 70 bcm gap between available export capacity and demand by 2035.

Figure 5.24 ▷ LNG demand in the STEPS and the ARC compared to existing and under-construction capacity, 2015-2040



LNG demand falls well below export capacity in the ARC, causing dilemmas for exporters

Note: LNG = liquefied natural gas.

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In the ARC, importing countries go further in seeking to reduce reliance on imported fuels. This effort affects demand for LNG – the marginal source of natural gas supply for nearly all importing countries. Despite rising global LNG capacity, LNG demand in the ARC is less than 100 bcm higher than 2025 levels, and the gap between available export capacity and demand in 2035 widens to around 260 bcm (Figure 5.24). Import demand could plausibly be constrained in this way in response to persistent worries about the security of gas supply, including a long tail of risks affecting the reliability of LNG exports from the Middle East.

If such an outcome on the demand side were to coincide with full availability of supplies from existing and under-construction LNG export facilities, this would bring a large surplus of LNG supply over demand. This surplus would exert strong downward pressure on gas prices, intensifying competition among suppliers. Rebound effects could be a powerful countervailing force that draws in additional demand and helps balance markets, but several factors could hold back a strong demand response to lower prices (Box 5.3).

Box 5.3 ▷ What could hold back a demand response to abundant LNG?

In the ARC, LNG demand grows by 70 bcm between 2025 and 2035. This is well below anticipated net growth in export capacity, which is set to expand by nearly 330 bcm to reach 940 bcm per year by 2035, based on all the projects that already exist or are under construction today. If all LNG supply is available, and all the new capacity comes online as planned, this mismatch implies sharp reductions in utilisation rates and the shutting-in of some capacity. Importers could, however, materially raise their imports instead to take advantage of loose market conditions and low prices. This raises the question of how likely it is that importing countries will act in this way – and, if not, why they might not choose to respond to abundant LNG supply and lower prices by increasing their LNG imports.

A key potential conduit for absorbing an LNG surplus is coal-to-gas switching. Near-term switching on economic grounds is most feasible in countries relying on higher-cost imported coal. We estimate that around 300 bcm of coal-to-gas switching potential exists on a short-term basis in LNG-importing countries in 2035. However, this would require very low gas prices, in some cases well below the "floor price" of delivering LNG. In the STEPS and the ARC, prices in the early 2030s fall towards the short-run marginal cost of supply, which is most likely to be set by US LNG. The cost of US feed gas depends crucially on market trends within the United States. With strong domestic demand growth, higher natural gas supply costs and a modest increase in LNG exports over this period, Henry Hub prices reach USD 4 per million British thermal units (MBtu) in 2035. Adding variable liquefaction, shipping and regasification costs suggests that delivering US LNG into key Asian import markets could cost around USD 6/MBtu on a short-run basis.

This price level is higher than the gas prices that are required to unlock significant additional coal-to-gas switching beyond the level of the STEPS (Figure 5.25). Moreover, delivering LNG is not likely to be sustainable in the long run at these prices, since they imply a return below the rates most projects require to recover invested capital. There

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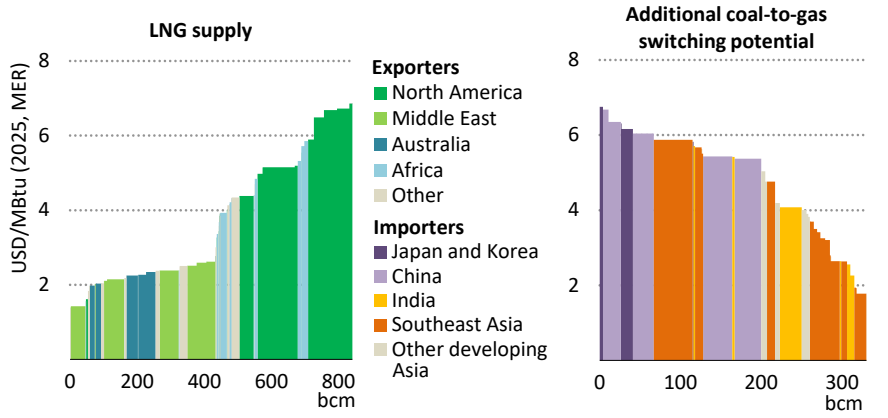
are also non-market barriers to wide-scale switching, such as contractual protections for coal plants and limits to the capacity of electricity or gas grids to absorb additional demand.

Figure 5.25 ▷ Short-run marginal cost of LNG supply and coal-to-gas switching potential beyond the level of the STEPS in 2035



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Abundant LNG supply could cause producers to sell at prices near short-run marginal costs; but most of the potential for coal-to-gas switching would require lower prices

Note: MBtu = million British thermal units.

Other elements that could prevent a meaningful demand response to lower prices in the ARC include:

- Gas importers may avoid a large build-out of import infrastructure. As a result of the 2026 energy crisis, importers may place more emphasis on developing domestic resources and less on developing new infrastructure to support imported fuels. In India and Southeast Asia, for example, the build-out of regasification terminals and domestic pipelines could follow current trends, whereas a meaningful absorption of the additional LNG capacity available in the STEPS or the ARC would require a sharp acceleration.
- Importers may be willing to pay a premium for domestic fuels and technologies to avoid imports. If governments in importing countries were to support domestic resources with subsidies, tax incentives and other tools, this would create a more difficult competitive environment for imported gas.

For buyers, the choices involved in meeting LNG demand in the ARC would be guided not just by price but also by a desire to maximise supplier and route diversification while securing volumes with a high degree of reliability and flexibility. Against this background, importers

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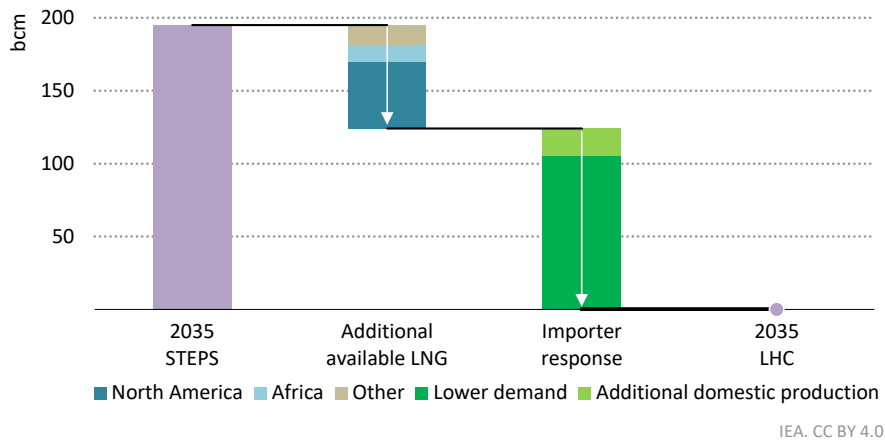
would be likely to strive for an appropriate balance of long-term contracts – which tend to reduce volume flexibility – and continued exposure to volatile, yet flexible and diverse, spot markets. In making these choices, buyers would have to manage trade-offs between lowering import dependence, securing supply at the lowest possible cost, buying from trusted suppliers and sustaining a diversified set of suppliers. In addition to questions about the degree to which Middle Eastern LNG returns to the market, there are uncertainties over whether sellers would be willing to concede on price or volume flexibility in order to maintain market share or offset the concerns that importers may have about continued dependence on LNG flowing through the Strait of Hormuz (Box 5.4).

Box 5.4 ▻ Can global LNG markets balance without the Strait of Hormuz?

Around 110 bcm, or 20% of global LNG trade, passed through the Strait of Hormuz in 2025. This volume increases in the STEPS to almost 200 bcm by 2035. It is much more difficult for LNG to bypass the Strait of Hormuz than for oil. The extent to which dependence on the Strait could be reduced is an open question: possible ways of reducing it include scaling up additional LNG supply and developing long-distance gas pipeline projects in other exporting regions, and maximising domestic production and reducing demand in importing regions. These options are explored in the Low Hormuz Case (LHC).

Figure 5.26 ▻ Differences in natural gas flows through the Strait of Hormuz in the STEPS and the LHC, 2035



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There is little scope for Qatar and UAE LNG to bypass the Strait of Hormuz, but importers could reduce demand and pursue alternative LNG

Around 70 bcm of available LNG capacity in 2035 is surplus to requirements in the STEPS. This surplus would be the first port of call for importing countries seeking to diversify away from volumes delivered via the Strait in the LHC (Figure 5.26). There is also scope

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for around 20 bcm of additional domestic production in importing regions relative to the STEPS, particularly in China and the European Union. But the main lever would be demand reduction. In the LHC, a reduction of around 105 bcm (compared with 275 bcm in the ARC) is sufficient to bring LNG flows through the Strait of Hormuz to zero.

While a combination of these factors could bring the LNG market into balance without exports from Qatar and the United Arab Emirates, none can be taken for granted. For example, Qatar and the United Arab Emirates are both low-cost suppliers and could offer concessions on price or volume flexibility to maintain market share. Continued uncertainty around the amount of LNG that might pass the Strait could increase global gas market volatility, making it hard to invest in alternative supply. There is also uncertainty about the level of future demand: much higher gas demand, as in the CPS, would mean that the loss of LNG available through the Strait of Hormuz would leave the market in a deficit of around 230 bcm in 2035 – a far larger amount than in 2026 – even with increased pipeline exports and additional domestic production in importers.

The trajectory for LNG in the ARC raises the question of whether surplus LNG production capacity is sustained, or whether some exporting assets are retired early. For suppliers able to sell LNG cargoes on a long-term take-or-pay basis, much of the volume and price risk may be passed to offtakers. For suppliers without firm offtake contracts, LNG cargoes would need to be sold on the spot market at prices close to short-run marginal cost. If prices were to fall below the cost of feed gas and variable operating expenses for a prolonged period, some liquefaction capacity would probably be shut in.

In practice, importers may be willing to accept a premium for a more diversified portfolio of supply sources. This premium could allow a broader range of suppliers to remain competitive than might otherwise be the case. In such a context, the ARC would be characterised by a higher share of long-term contracts governing LNG trade, particularly where such arrangements were perceived to enhance security of supply and price stability when compared to continued exposure to volatile, yet flexible and diverse, spot markets. This would imply a greater share of gas being priced against lagged indices, including oil-linked benchmarks, helping to smooth price volatility. There would still be large risks for some exporters, and they might need to write down some of the value of existing assets or decide not to commit additional capital expenditure over time in new upstream gas fields, liquefaction terminals, LNG carriers and other infrastructure.

5.4.5 What would higher domestic coal production mean for coal trade?

In the ARC, global coal demand declines by just under 13% between 2025 and 2035, compared with 14% in the STEPS. Since major importers meet a greater share of their needs from domestic resources, however, coal trade contracts more than production, falling by more than 30% in the ARC to 2035, compared with 18% in the STEPS.

In China, coal demand in the ARC is slightly higher than in the STEPS as coal displaces some use of imported natural gas in the power sector. However, a push to develop more domestic

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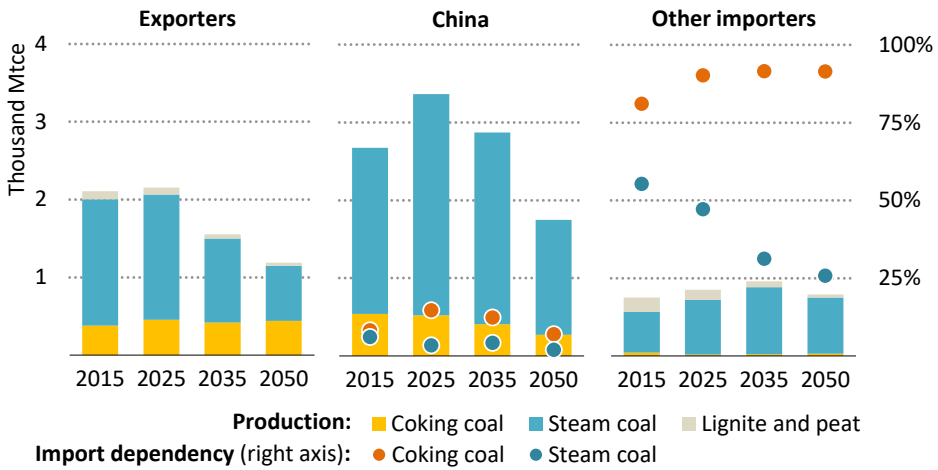
resources means that domestic supply meets 95% of overall demand in 2035 (Figure 5.27), compared with around 90% in the STEPS. As a result, China's coal imports fall by nearly half to 2035 in the ARC, compared with a 25% reduction in the STEPS. The difference in China's coal imports between the ARC and the STEPS in 2035, at over 100 million tonnes of coal equivalent (Mtce), is greater than Korea's entire domestic coal use in 2025.

Figure 5.27 ▷ Coal production and import dependency by region and by coal type in the ARC, 2015-2050



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Coal production ramps up in small volumes in several net importers to satisfy domestic demand, while net exporters see output decline as markets contract

In India, coal demand in the power sector is slightly higher in the ARC than in the STEPS. Increased domestic coal production in the ARC means that steam coal imports decline from almost 150 Mtce in 2025 to around 30 Mtce by 2035, reducing overall import dependence from around 30% today to 15%. However, the picture is different for coking coal. Rising steel production drives a 55% increase in coking coal demand by 2035, and India's limited domestic reserves of suitable quality mean that much of this increase is met through imports.

The preference of major importers for domestic supply in the ARC means the adjustment in production falls on export-oriented producers, especially steam coal exporters (Figure 5.28): steam coal trade falls by 40% (around 350 Mtce) to 2035 in the ARC, compared with a 25% decline in the STEPS. Indonesia sees the largest decline in steam coal exports in absolute terms, with production falling by around 40% to 2035 as import demand weakens across China, India and other Asian markets. Australia, Russia and South Africa also see larger declines than in the STEPS, with steam coal production in each country falling by more than 30% to 2035.

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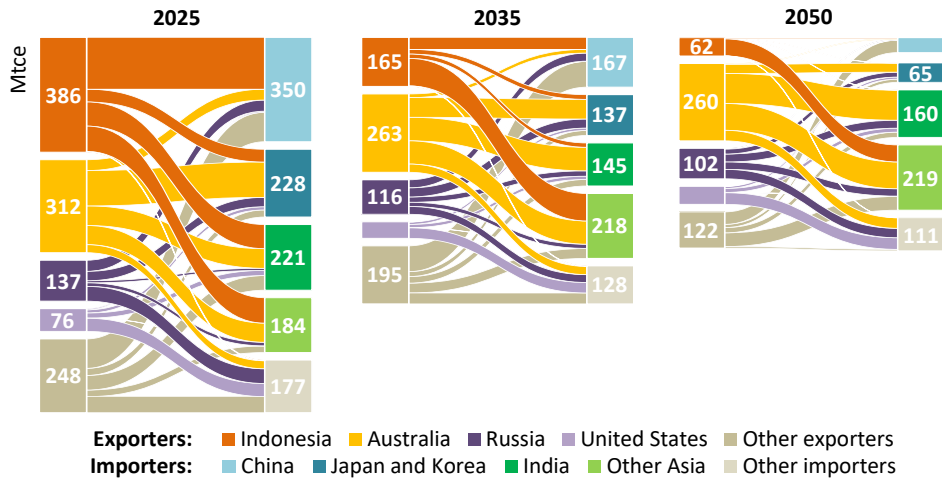
Coking coal follows a different trajectory. Coking coal resources are more geographically concentrated and are more difficult to replace with domestic production. Continued growth in steel production across developing Asia underpins import demand in the ARC, and international coking coal trade remains broadly stable to 2035 before increasing towards 2050. Australia overtakes Indonesia as the world's largest coal exporter, supported by resilient steam coal demand from Japan and Korea, and by rising coking coal imports in India, while Mongolia maintains a stable export position through continued sales to China.

Figure 5.28 ▷ Net coal trade in the ARC, 2025-2050



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Global coal trade contracts sharply as importers switch fuels or expand domestic production, though strong coking coal demand supports Australian exports

Notes: The largest coal exporters and importers are ordered by net coal trade in energy-equivalent terms in 2025. 'Other exporters' include South Africa, Mongolia, Colombia, Canada, Caspian, Mozambique, New Zealand and Venezuela; 'Other importers' include Europe, the Middle East, North Africa, and the rest of Latin America and sub-Saharan Africa.

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PART C
REACHING LONG-TERM GOALS

The world is currently not on track to meet the temperature goals of the Paris Agreement, with projections based on current policy settings and market trends set to result in warming of well above 2 °C. Delays in taking action to reduce emissions mean that it is now no longer possible to avoid overshooting the 1.5 °C limit. There are still pathways which return warming to this level by 2100, but they require rapid and ambitious action to reduce emissions.

This section analyses an updated global pathway to net zero emissions from the energy sector by 2050 which takes account of the latest emissions, investment and technology trends. It assesses how nationally determined contributions under the Paris Agreement measure up against what is needed to meet the temperature goals set out in that Agreement. It also sets out milestones for 2035 and 2040 which could bring energy sector emissions back in line with pathways that limit warming to 1.5 °C after a period of overshoot.



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The outlook for energy transitions

Climate policies and emissions

SUMMARY

- Global economy-wide greenhouse gas (GHG) emissions rose to a record high of 54.1 gigatonnes (Gt) of carbon dioxide equivalent in 2025. The energy sector has contributed two-thirds of the rise in global GHG emissions over the last decade, with the power sector accounting for the largest share of the increase, despite the rapid growth of low-emissions generation.
- The energy sector features in almost all new Nationally Determined Contributions (NDCs) submitted under the Paris Agreement since December 2023, but only around 30% reference the goal to triple global renewable energy capacity by 2030, and fewer still refer to other COP28 goals. In aggregate, the new NDCs do not signal a strengthening of ambition compared with previous ones.
- Against this background, the IEA Net Zero Emissions by 2050 (NZE) Scenario translates the 1.5 °C goal of the Paris Agreement into a global energy sector pathway built on four pillars: low-emissions power generation; efficiency improvements and electrification of end-uses; low-emissions fuels; and carbon dioxide capture and storage. As countries gear up to start the second Global Stocktake in late 2026, the NZE Scenario provides a benchmark for tracking progress and policy ambitions.
- Energy-related CO_2 emissions rapidly decline in the NZE Scenario, more than halving to less than 19 Gt by 2035. Global average temperatures reached around 1.4 °C above pre-industrial levels in 2025. In this scenario, warming peaks just below 1.7 °C by mid-century before falling back to below 1.5 °C by 2100. In the Current Policies Scenario, warming reaches 2.9 °C by 2100, while rising to around 2.5 °C and 2.4 °C in the Stated Policies Scenario and the Additional Response Case respectively.
- In the NZE Scenario, electricity transitions accelerate. Low-emissions sources rise to account for almost 90% of generation in 2035, up from 42% today. Electrification also plays an increasing role in reducing end-use emissions: the share of electricity in total final energy consumption rises above 35% by 2035. Nuclear power, low-emissions fuels such as hydrogen, and carbon capture are critical too. Average annual global clean energy investments triple to around USD 4.5 trillion in the decade to 2035, the average household energy bill falls by almost 10% in fuel-importing regions, and the rate of energy sector workforce expansion rises to 1.8% per year.
- The NZE Scenario reshapes energy security. Fuel import expenditures fall rapidly from around 2.3% of global gross domestic product today to 0.6% by 2035, reducing exposure to international fuel markets. At the same time, growing electrification and low-emissions energy deployment increase the importance of electricity security and of robust and diversified technology and mineral supply chains.

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6.1 Introduction

A decade after the ratification of the Paris Agreement, the global energy system is undergoing rapid but uneven change. Market momentum and stronger policies have helped accelerate the deployment of low-emissions energy; climate-related energy policy frameworks have broadened across most major economies; and climate pledges now cover most global energy-related emissions. However, developments have not been linear; in the past two years, some policies have been delayed, weakened or phased out. Moreover, progress is taking place against a backdrop of steadily rising demand for energy. Despite the momentum of low-emissions technologies, energy-related greenhouse gas emissions reached a record high in 2025, and the world remains far from trajectories consistent with the temperature goals of the Paris Agreement.

The 2026 energy crisis is highlighting the economic and strategic risks of reliance on imported fossil fuels. Governments are responding by accelerating investment in domestically available energy sources, including renewables and nuclear power, while high fuel prices are strengthening the case for electric vehicles. As a result, additional response measures to improve energy security increasingly reinforce efforts to cut emissions, strengthening the alignment between energy security priorities and broader global climate and net zero objectives. In the Additional Response Case (ARC), carbon dioxide (CO_2) emissions are reduced by almost 9% against 2025 levels, 3.4 gigatonnes (Gt) below Current Policies Scenario (CPS) levels in 2035. Energy security concerns on their own do not yet enable the world to get back on track with the mitigation objectives of the Paris Agreement. Doing so requires an even faster deployment of low-emissions technologies and accelerated energy sector transitions.

The Net Zero Emissions by 2050 (NZE) Scenario translates the goal of limiting warming to 1.5 °C into a global pathway for the energy sector. It represents one way, but not the only one, for the energy sector to reach net zero emissions by 2050. Since its introduction, the NZE Scenario has been updated each year in line with shifts in energy investment, technology developments and emissions. The NZE Scenario was substantially revised for the *World Energy Outlook 2025* (*WEO-2025*) to take account of continued high emissions in recent years and sluggish deployment of some low-emissions energy technologies. Reflecting these trends, it was based on a trajectory involving smaller emissions reductions in the near term and found overshoot of the 1.5 °C goal is now inevitable. Returning to below 1.5 °C still requires extremely rapid reductions of emissions in the near term; it also now depends on the widespread deployment of CO_2 removal technologies that are currently unproven at large scale.

For this year's *World Energy Outlook*, the NZE Scenario has once again been updated. This chapter begins by assessing recent trends in emissions, climate pledges and energy policies. It then explores the transformation of the energy sector required in the NZE Scenario and considers its implications for energy security, investment, affordability and employment, as well as for emissions and global temperatures.

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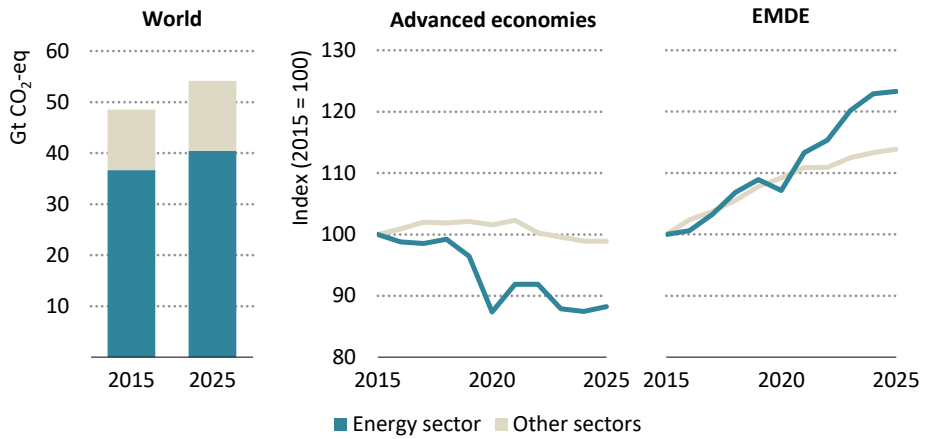
6.2 Current trends in global greenhouse gas emissions

6.2.1 Global economy-wide greenhouse gas emissions

Global economy-wide greenhouse gas (GHG) emissions[1] rose by 0.7% to a record high of 54.1 gigatonnes of carbon dioxide equivalent (Gt CO_2-eq) in 2025. The energy sector accounted for around 75% of the total and for nearly 65% of the increase since 2024 (Figure 6.1). Intergovernmental Panel on Climate Change (IPCC) energy sector emissions include fossil fuel combustion emissions (the vast majority of the total) and fugitive emissions (mostly methane emitted during the extraction and production of fossil fuels).[2]

Figure 6.1 ▷ Global economy-wide GHG emissions excluding LULUCF, 2015-2025



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Energy sector emissions remain the main driver of global emissions growth, while trends diverge between advanced economies and EMDE

Notes: Gt CO_2-eq = gigatonnes of carbon dioxide equivalent; EMDE = emerging market and developing economies. Energy emissions are defined according to IPCC (Intergovernmental Panel on Climate Change) Category 1, accounting for fuel combustion and fugitive emissions. 'Other sectors' includes Categories 2 (Industrial process and product use), 3 (Agriculture), 4 (Waste) and 5 (Other). EDGAR excludes land use, land-use change and forestry (LULUCF) emissions and applies IPCC AR5 (Fifth Assessment Report) GWP (Global Warming Potential) values. Category 2F and Category 5 emissions are excluded from indexed trends.

Source: IEA analysis of the Emissions Database for Global Atmospheric Research (EDGAR) Community GHG Database (EDGAR, 2026).

[1] Excluding net emissions from land use, land-use change and forestry (LULUCF). The United Nations Environment Programme Emissions Gap Report 2026 (UNEP, 2026) suggested that when LULUCF emissions are included, global GHG emissions are 58.4 Gt CO_2-eq, a decline of 0.1 Gt CO_2-eq from 2024 levels. It also notes it is not yet possible to conclude a drop in emissions in 2025 due to the high uncertainty range.

[2] This definition differs from energy-related emissions discussed elsewhere, which include industrial process emissions from energy-intensive industries.

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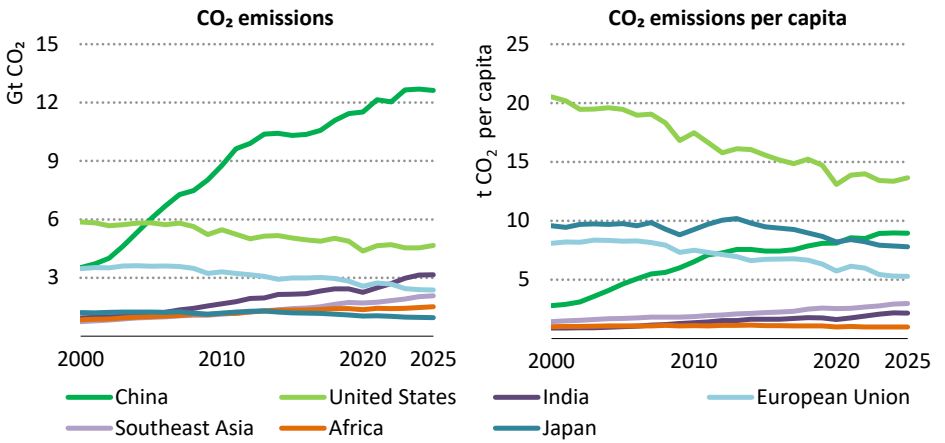
Over the past decade, the energy sector has been responsible for 67% of the growth in global GHG emissions. The increase over this period has been concentrated in emerging market and developing economies: the energy sector has accounted for 73% of the total increase in GHG emissions in these countries. In advanced economies, energy sector emissions have declined, while emissions from most other sectors have remained broadly stable.

6.2.2 Global energy-related CO_2 emissions

Global energy-related and industrial process CO_2 emissions reached a record high of 38.7 Gt CO_2 in 2025, but year-on-year emissions growth was less than 1%. Over the past two decades, coal has accounted for around half of the increase in global CO_2 emissions from fuel combustion, although its contribution to emissions growth has begun to weaken in recent years.

Both absolute and per capita emissions have declined over the past 25 years in advanced economies such as the European Union and the United States. Emissions from China have more than tripled over the same period (Figure 6.2), but emissions growth has slowed over the last three years, and China's emissions declined in 2025. Emissions in other emerging market and developing economies, including Africa and Southeast Asia, continue to rise as demand for energy services expands.

Figure 6.2 ▷ Energy-related CO_2 emissions, total and per capita, 2000-2025



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Energy-related CO_2 emissions remain at record highs, but trends vary across regions

Note: Gt CO_2 = gigatonnes of carbon dioxide; t CO_2 = tonnes of carbon dioxide.

Sectoral trends also vary. Since 2000, CO_2 emissions from power generation and industry have grown faster than those from other sectors, reflecting rising electricity demand and industrial production in emerging market and developing economies. Direct emissions from

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transport have also grown strongly, while those from buildings have grown more slowly. Since 2019, the electricity and heat generation sector has accounted for around 90% of the global increase in energy-related emissions.

Record energy-related CO_2 emissions in 2025 were accompanied by record energy-related methane emissions of 4.5 Gt CO_2-eq (3.7 Gt CO_2-eq from fossil fuel production only). Methane emissions from the production of oil and gas reached a record high of 2.4 Gt CO_2-eq in 2025 and have risen by 25% since 2000. Methane emissions from coal production have grown even faster over the same period, increasing by nearly 60%. Methane remains an important component of energy sector emissions, and rapid reductions in methane emissions would contribute significantly to slowing near-term warming.

Despite evidence of the decoupling of economic and emissions growth in some economies (Box 6.1), global energy-related emissions are still increasing. The lower end of the temperature objectives of the Paris Agreement is already looking very challenging, and, if current trends continue, will soon move out of reach.

Box 6.1 ▻ Where is decoupling happening and why?

For much of modern history, economic growth has been closely tied to rising energy use and energy-related emissions. This relationship is now weakening in many parts of the world. In many advanced economies, including the European Union and the United States, gross domestic product (GDP) has risen since 2010, while energy demand has either remained broadly flat or declined and GHG emissions have fallen (Figure 6.3). This reflects structural changes in these economies, as well as the increasing deployment of low-emissions technologies. The same decoupling is also visible when emissions embodied in trade are taken into account: consumption-based GHG emissions among advanced economies have steadily declined since 2007 (OECD, 2025a).

China is beginning to show signs of a similar decoupling between GDP and emissions. While China's economy continues to grow rapidly, its GHG emissions have plateaued in recent years, and energy demand has grown more slowly than GDP. This reflects rapid growth in renewable power generation, a levelling-off of coal-fired generation and a gradual shift away from energy-intensive industries – such as steel and cement – towards less energy-intensive, higher-value manufacturing.

Other emerging market and developing economies remain at an earlier stage of this process, with GDP, energy demand and GHG emissions still growing together as industrial activity expands and rising incomes increase demand for mobility, cooling and other modern energy services. GDP is nevertheless growing faster than energy demand and emissions in countries such as India. This is the result of the very different technology environment today compared with earlier waves of industrialisation. More efficient equipment, vehicles and appliances are now commercially available worldwide, and solar photovoltaics (PV) and other low-emissions energy technologies are increasingly among

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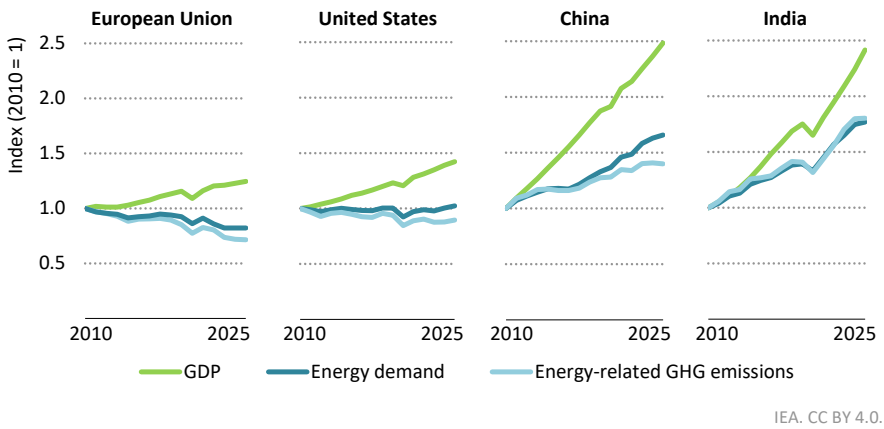
the lowest-cost options for new energy supply. Stronger policy support would help to further accelerate the decoupling of economic growth and GHG emissions around the world.

Figure 6.3 ▻ Economic and energy indicators by region, 2010-2025



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Energy-related greenhouse gas emissions have become less closely tied to GDP growth and energy demand in a number of regions

Note: GHG = greenhouse gas; GDP = gross domestic product.

6.3 Climate pledges and policy implementation

6.3.1 Policy frameworks for delivering climate commitments

Since the adoption of the Paris Agreement and of new climate targets associated with it, governments have expanded and strengthened their policy frameworks to support low-emissions energy transitions through a diverse range of instruments, including fiscal incentives, pricing mechanisms, regulatory measures and trade policies. These policies have increasingly focused on improving overall energy efficiency, accelerating the electrification of end-uses and supporting the deployment of low-emissions energy technologies. In many cases, they have synergies with energy security policies.

Energy efficiency and fuel switching policies

Energy efficiency and fuel switching policies are core components of energy policy frameworks globally. Since the first global oil crisis in 1973, more than 130 countries have adopted at least one energy efficiency standard. The momentum has grown since 2020, with 82 countries adopting or revising an energy efficiency standard for industrial motors, air conditioners or vehicle fuel economy (IEA, 2026a). Additionally, 49 countries now have

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biofuel blending mandates in place in their transport sectors; the 2026 energy crisis has accelerated the adoption of new regulations – notably in Southeast Asia, where Indonesia has begun implementing its B50 mandate and Viet Nam has accelerated the implementation of its E10 programme.

Several energy efficiency regulations were revised, withdrawn or delayed in different jurisdictions in 2025. Notable examples were the reset of fuel-economy standards in the United States and the relaxation of standards for passenger cars in Canada, the European Union and the United Kingdom. Across the world, efficiency standards covering 30% of global energy demand were made less stringent or saw their implementation delayed in 2025, while standards covering slightly less than one-fifth of global energy demand were strengthened.

Electrification policies

The electrification of end-use sectors has gained momentum during 2026, accelerated by the 2026 energy crisis and the desire to strengthen energy security by reducing fossil fuel imports. A few national electrification plans and end-use sector strategies have emerged, including France's electrification plan (April 2026), Canada's National Strategy for an Electrified Economy (May 2026) and the European Commission's electrification action plan (July 2026). However, such plans remain relatively rare (IEA, 2026b).

In 2025, government energy spending dedicated to end-use electrification increased to USD 80 billion. This represented around 12% of total government energy spending, up from just 3% ten years before. Road transport was the main beneficiary, with much of the spending focused on the adoption of electric vehicles. Direct support for electrification in buildings and industry remained more limited, as many spending programmes cover broader efficiency or decarbonisation measures rather than targeted fuel switching to electricity. However, several support programmes have been scaled back in recent years, notably in Sweden in 2022, Belgium and the Netherlands in 2024, and the United States in 2025, while China reduced support for electric vehicle purchases by replacing its full purchase tax exemption with a 50% exemption from January 2026. In aggregate, government support per electric car steadily declined over the past decade as sales increased, reflecting that rising adoption has been driven by structural cost reductions in most regions (IEA, 2026c).

Spending is not the only tool governments have at their disposal. Regulatory measures can also bring about change, and they are being used in some countries to encourage a switch from other fuels to electricity. In 2026, France reaffirmed its ban on gas boilers in new buildings from 2027 in favour of heat pump installations. The United Kingdom mandated in 2024 that 100% of new car and van sales must be zero emission by 2035. There have also been some recent changes to existing regulatory measures – notably in Canada, which announced in 2026 that it would repeal the Electric Vehicle Availability Standard, to be replaced by more stringent GHG emissions standards. The past standard required manufacturers to meet increasing electric vehicle sales targets that had been set to reach 100% by 2035.

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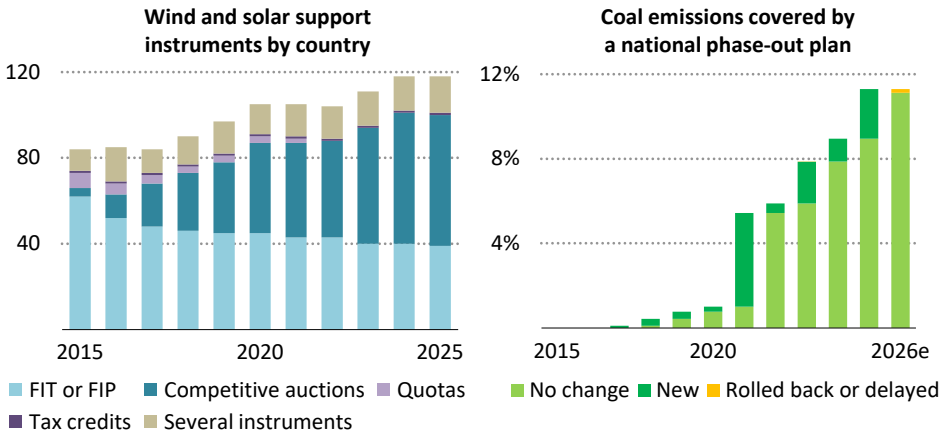
Power generation policies

Renewable electricity support mechanisms are evolving from fixed feed-in tariffs and tax credits towards competitive auctions and market-based instruments such as corporate power purchase agreements (Figure 6.4). In 2025, China introduced a major reform by replacing long-term fixed feed-in tariffs for renewable electricity with a competitive auction-based system. Public investment support for the power sector continues to expand, reaching an estimated USD 206 billion in 2025, more than double its level in 2015.

Figure 6.4 ▷ Low-emissions electricity policy development, 2015-2026e



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Renewable energy support schemes are shifting towards market-based approaches, and the number of countries planning to phase out unabated coal has grown

Note: FIT = feed-in tariff; FIP = feed-in premium; 2026e = estimated values for 2026.

Nuclear power is receiving renewed support in many countries. In the United States, several executive orders have been issued to strengthen the sector, including by uprating power at existing reactors, accelerating regulatory approvals and developing advanced reactors. Japan has signalled its intention to replace reactors, and it has published a new outlook with the aim of enhancing predictability for stakeholders and maintaining and strengthening the nuclear supply chain and workforce. Interest in reintroducing nuclear energy is also growing in some countries, including Italy, which in 2026 adopted an enabling law to reintroduce nuclear power by mandating the development of a new regulatory framework.

Since 2015, 38 countries, representing more than 10% of global CO_2 emissions, have committed to phase out unabated coal-fired power generation in national strategies. Recent milestones include the completion of coal power phase-outs in the United Kingdom, Slovakia and Ireland. However, recent global energy crises have delayed the planned phase-out of coal power in countries including France and Italy.

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Methane policies

Launched in 2021, the Global Methane Pledge is a collective commitment by 159 countries and the European Union to reduce global methane emissions by at least 30% from 2020 levels by 2030. Industry's willingness to take steps to reduce emissions has increased in parallel in recent years, as exemplified by the launch of the Oil and Gas Decarbonization Charter in 2023 and the steady expansion of the United Nations Environment Programme's Oil and Gas Methane Partnership 2.0 (OGMP 2.0). If fully implemented, these international initiatives, together with the policies and regulations in place in countries today, should reduce fossil fuel methane emissions by around 25% by 2035, as demonstrated in the Stated Policies Scenario (STEPS).

A growing number of countries have introduced tried-and-tested measures to limit fossil fuel methane emissions, including requirements for leak detection and repair and restrictions on venting and flaring (IEA, 2026d). Some countries have had such measures in place for decades: Norway, for example, banned non-emergency flaring in 1971 and introduced a tax on natural gas venting and flaring in 2015. More recently, legislation targeting methane emissions has been enacted in Canada, Indonesia and Nigeria, while the European Union has begun implementing its Methane Regulation, including requirements that progressively extend to fossil fuel imports. China also revised the scope of its voluntary carbon market in December 2024 to include methane emissions from coal mines. In addition, nearly 100 countries either have completed or are developing national methane action plans.

6.3.2 Taking stock of the latest climate pledges

Nationally Determined Contributions (NDCs) are the primary way in which countries communicate their national climate targets under the Paris Agreement. Submitted every five years, each successive NDC is expected to represent a progression beyond the previous one and to be as ambitious as possible. The new NDCs submitted in 2025 and 2026 are intended to set new targets for 2035 to guide emissions mitigation through to that date.

As of October 2026, 136 new NDCs had been submitted to the United Nations Framework Convention on Climate Change (UNFCCC).[3] Compared with the first round of commitments, many new NDCs place greater emphasis on economy-wide targets, include clearer implementation frameworks and link targets to longer-term net zero strategies. However, NDCs continue to vary considerably in their scope, sectoral coverage and level of detail. More than four-fifths of global energy-related GHG emissions are now covered by new NDCs.

The first Global Stocktake, which concluded at the 28th Conference of the Parties (COP28) in 2023, identified a set of important energy-related targets, including tripling global renewable energy capacity and doubling the rate of energy efficiency improvements by 2030,

[3] This count as of 7 October 2026 includes NDC submissions made after the conclusion of the first Global Stocktake at COP28. The European Union and its member states are treated as a single Party. The United States is excluded from the count, as it is no longer a Party to the Paris Agreement following its withdrawal, which took effect in January 2026.

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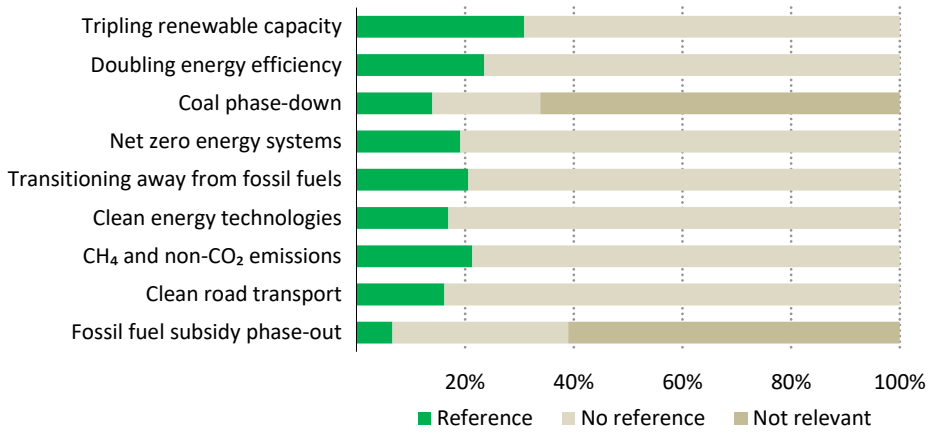
accelerating methane emissions reductions, transitioning away from fossil fuels in energy systems, and phasing out inefficient fossil fuel subsidies (UNFCCC, 2024). The current NDC cycle therefore provides an early indication of how the COP28 energy outcomes are being translated into national climate strategies and policy planning. References to these outcomes remain limited and uneven across the new NDCs. Around 30% of submissions refer to tripling renewables, and a considerably lower percentage refer to energy efficiency, methane emissions, transitions away from fossil fuels or fossil fuel subsidy reform (Figure 6.5).

Figure 6.5 ▷ Share of new 2035 NDCs with reference to COP28 energy goals



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COP28 energy outcomes are only partially reflected in new 2035 NDCs

Notes: CH_4 = methane. The NDC of the United States is excluded from this analysis, as the country is no longer a Party to the Paris Agreement. The analysis covers new NDCs submitted from December 2023 until 7 October 2026.

At the aggregate level, the latest NDCs do not signal a marked increase in ambition relative to previous submissions. In some cases, they indicate slower rates of emissions mitigation than those associated with earlier commitments (Figure 6.6). The latest NDCs also reveal contrasting patterns between groups of countries. In advanced economies[4], targets for 2035 in newly submitted NDCs imply faster annual emissions reductions than in both previous rounds of NDCs and current policy trajectories, suggesting a rising level of climate ambition that is running ahead of implementation. In emerging market and developing economies, on the other hand, new 2035 NDCs do not imply faster emissions mitigation than the previous round of revised 2030 NDCs and what is seen under current policy settings, suggesting that international commitments are lagging behind domestic policies. As emissions rise year by year, the gap between climate commitments and what is needed to meet Paris Agreement objectives increases, and the path to getting back on course gets steeper (Box 6.2).

[4] The NDC of the United States is excluded from this analysis, as the country is no longer a Party to the Paris Agreement. International bunkers are also excluded from the estimates.

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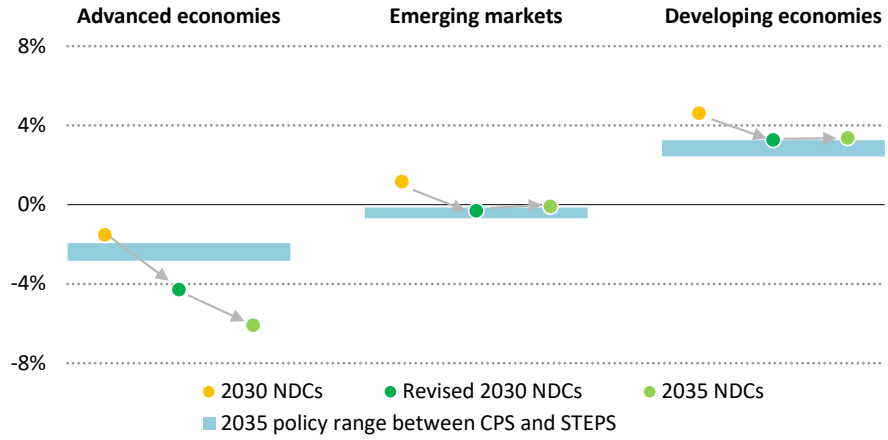
Figure 6.6 ▷ Average annual change in energy-related CO_2 emissions implied by 2030 and 2035 NDCs and policy range



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The latest NDCs do not imply a significant acceleration in energy-related CO_2 mitigation in all regions

Notes: NDC = Nationally Determined Contributions. Emerging markets includes emerging market and developing economies with gross domestic product per capita higher than or equal to USD 20 000 at purchasing power parity (2025, PPP). Developing economies includes emerging market and developing economies with gross domestic product per capita lower than USD 20 000 at purchasing power parity (PPP). Policy range displays the difference in annual rate between the Current Policies Scenario and the Stated Policies Scenario for each regional grouping. The NDC of the United States is excluded from the analysis, as the country is no longer a Party to the Paris Agreement. International bunkers are also excluded from the estimates.

Box 6.2 ▷ Are countries on track to meet 2030 NDCs?

Delays in implementation have made meeting the targets set out in 2030 NDCs increasingly difficult. Although the rate of emissions growth has slowed since 2021, global energy-related emissions have continued to increase since the Paris Agreement. This has raised the level of mitigation needed to achieve the emissions reductions targeted by revised NDCs. While the first 2030 NDCs, submitted in 2016, implied an implementation gap of 0.5 percentage points annually between what was targeted and countries' historical emissions, the implementation gap widened to 1.6 percentage points with the new round of NDCs in 2021 (Figure 6.7).

Under today's policy settings, progress remains insufficient to achieve NDC targets for 2030. Although energy-related emissions are projected to decline by around 0.2% annually in the STEPS between 2025 and 2030, the implementation gap does not decrease over time. Achieving the 2030 NDC targets requires an annual reduction of around 1.8% from 2025 to 2030 – a 1.6 percentage point difference from the STEPS.

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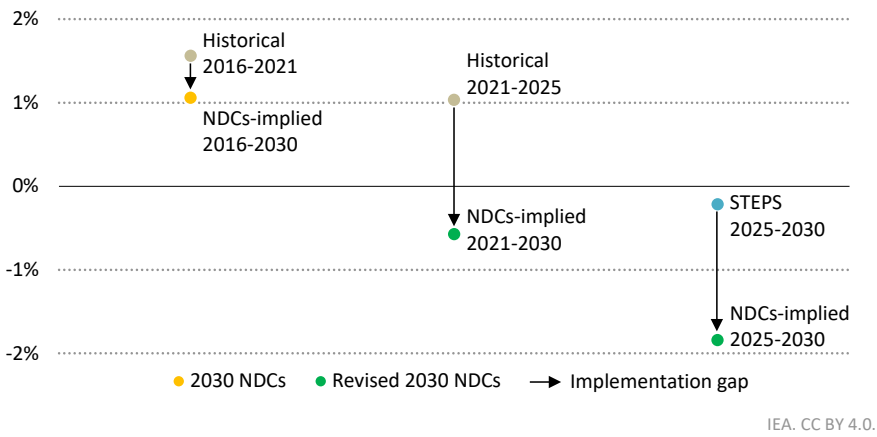
Closing this gap requires stronger policy implementation and additional investment in the near term to accelerate the mitigation of emissions.

Figure 6.7 ▷ Historical and NDCs-implied annual change in global energy-related emissions, 2016-2030



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Delaying implementation shifts a larger share of the required emissions reductions into the remaining years before the target date

Notes: NDC = Nationally Determined Contributions; STEPS = Stated Policies Scenario. The NDC of the United States is excluded from the analysis, as the country is no longer a Party to the Paris Agreement. International bunkers are also excluded from the estimates.

6.4 Energy pathways in the NZE Scenario

6.4.1 Key milestones to reach global net zero energy emissions by 2050

Achieving net zero emissions from the energy sector is a critical part of pathways that limit warming in line with the goals of the Paris Agreement. The IEA NZE Scenario is a normative scenario that represents one global pathway for the energy sector to reach net zero emissions by 2050 and return warming to below 1.5 °C by 2100. It relies on a continuous assessment of the potential to mitigate emissions across sectors and technologies – driven by costs, technological maturity, market conditions, available infrastructure and policy preferences.

Key indicators – such as the deployment of low-emissions power generation, the electrification of end-uses and the scaling up of innovative low-emissions fuels and technologies – offer a framework to understand deployment trends, track progress and inform future policies. As countries gear up to start the next Global Stocktake under the Paris Agreement, setting and analysing key milestones becomes particularly important (Table 6.1).

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Table 6.1 ▷ Key indicators in the NZE Scenario, 2035, 2040 and 2050

		NZE Scenario		
	2025	2035	2040	2050
Installed renewables capacity (GW)	5 800	20 500	28 400	37 400
Installed nuclear capacity (GW)	420	730	980	1 200
Installed battery capacity (GW)	300	3 340	4 860	7 100
Installed transmission and distribution lines (million km)	86	120	140	190
Emissions intensity (t CO_2 per thousand USD)	0.17	0.06	0.03	<0.01
Share of electricity in final energy consumption	23%	35%	45%	61%
Share of electric vehicles in passenger car stock	6%	36%	58%	87%
Heat pump sales (GW)	110	380	460	590
Share of unabated fossil fuels in total energy supply	72%	41%	23%	6%
Sustainable fuel supply (EJ)	7	33	45	64
Share of hydrogen and hydrogen-based fuels in total final consumption	<1%	1%	3%	5%
CO_2 captured (Gt)	0.1	2.2	3.9	6.4
CO_2 removed (Gt)	<0.1	0.7	1.2	2.7
Fossil fuel methane emissions (Gt CO_2-eq)	3.7	0.8	0.4	0.1
Fossil fuel upstream methane intensity (kg CH_4 per GJ)	0.19	0.06	0.04	0.01

Notes: NZE Scenario = Net Zero Emissions by 2050 Scenario; GW = gigawatt; km = kilometre; EJ = exajoule; kg = kilogram; GJ = gigajoule. Emissions intensity accounts for gross domestic product in 2025 USD PPP terms. Upstream methane intensity is calculated as mass of methane emissions divided by marketed fossil fuel (coal, oil and gas) production in energy terms.

6.4.2 Electricity generation

Electricity plays a rapidly growing role in the global energy system. In the NZE Scenario, the rise in low-emissions generation outpaces the increase in electricity demand, allowing it not only to meet that increase but also to displace unabated fossil fuel generation. This marks a shift from the past decade, when rapid growth in low-emissions generation occurred alongside continued growth in coal- and gas-fired generation. Delivering this transformation requires accelerating the use of low-emissions sources of generation, including renewables and nuclear, while investing in electricity grids, storage and other sources of flexibility. The goal in the NZE Scenario is to enable the power sector to reach net zero emissions in the early 2040s while supporting increasingly widespread electrification across end-use sectors.

Installed capacity and deployment

In the NZE Scenario, global power capacity increases more than two and a half times to over 28 000 gigawatts (GW) by 2035. Installed low-emissions power capacity rises to three and a

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half times today's level, while the installed capacity of unabated fossil fuel power plants declines by about 30% to 2035. Solar PV and wind account for 90% of the increase in low-emissions sources, while hydropower and nuclear together contribute about 5%. Achieving this expansion requires the deployment of low-emissions sources to accelerate and then remain at historically high levels over the coming decade.

Solar PV capacity additions approached 635 GW for the first time in 2025, 14% higher than the previous year. These solar PV additions accounted for more than three-quarters of total low-emissions capacity additions in 2025 and took installed solar PV capacity to over 2 800 GW, more than any other power generation technology today. Wind capacity additions reached around 155 GW in 2025, increasing by 34% from 2024 and setting a new record. Deployment of both technologies accelerates further in the NZE Scenario, with annual additions of over 1 200 GW of solar PV and 450 GW of wind in 2035. This rapid build-out brings installed solar PV capacity to around 13 000 GW and wind capacity to 5 000 GW by 2035, with both sources combined accounting for more than 60% of all power capacity by that date. Both continue to grow thereafter to 2050.

Nuclear power is gaining renewed momentum as countries seek to expand low-emissions dispatchable capacity and strengthen electricity security. Nuclear capacity remained stable globally in 2025, with 3 GW retired and 3 GW added, but almost 90 GW of new capacity is now under construction in 17 countries, setting the scene for a major increase over the coming years. In the NZE Scenario, nuclear capacity increases by nearly 75% from current levels by 2035 and reaches around 1 200 GW by 2050. This requires the nuclear industry to start scaling up in the late 2020s and bringing new reactor designs to the market, including for small modular reactors, to make rapid growth possible in the 2030s. Such growth depends on robust supply chains, skilled labour and project development capabilities, efficient permitting and licensing processes, and sustained long-term policy support.

Generation mix

Unabated fossil fuels provided close to 60% of global electricity generation in 2025 and emitted 14 Gt of CO_2. Net emissions in the power sector fall to zero in the NZE Scenario in the 2040s, requiring the rapid expansion of low-emissions sources to transform the electricity generation mix (Figure 6.8). As a result of the rapid build-out of renewables, their share in total electricity generation rises from one-third in 2025 to three-quarters by 2035. The share of nuclear rises from just under 9% in 2025 to 10% in 2035. Between them, low-emissions sources not only meet all future growth in demand for electricity, but they also progressively reduce the share of existing demand met by unabated fossil fuel generation, which falls to less than 5% of global electricity generation by 2040. Some fossil fuel capacity remains in operation where needed for adequacy and flexibility, but a dominant share is equipped with carbon capture, utilisation and storage (CCUS) or uses low-emissions fuels such as hydrogen, ammonia or biogases. This transformation reduces fossil fuel use and import requirements in the power sector around the world.

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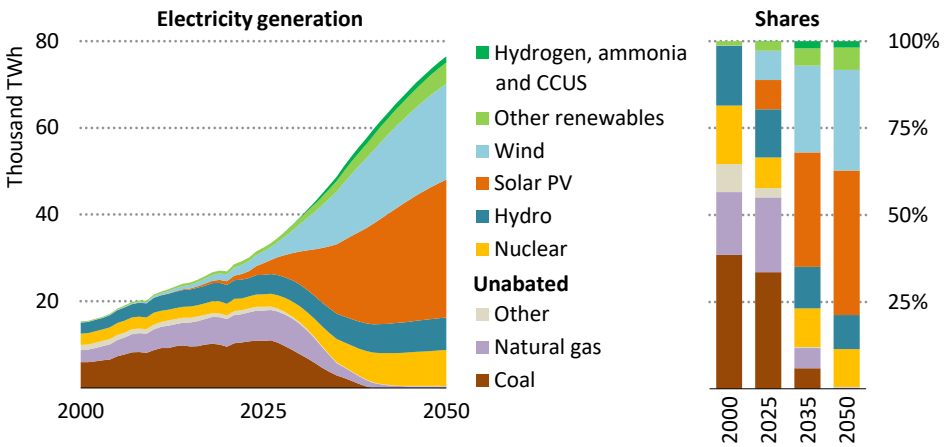
Figure 6.8 ▷ Global electricity generation in the NZE Scenario, 2000-2050



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Rapid growth in all low-emissions sources enables the electricity sector to phase out unabated fossil fuels and reach net zero by the early 2040s

Notes: TWh = terawatt-hour; CCUS = carbon capture, utilisation and storage; PV = photovoltaics. Other renewables include bioenergy, geothermal, concentrating solar and marine power. Unabated other includes oil, non-renewable waste and other sources.

Security, flexibility and grids

Electricity security has been a cornerstone of power systems for more than a century, but its importance is growing as electricity increasingly powers economies around the world. Electricity systems need sufficient resources to meet demand at all times, including during periods of high demand and low wind and solar output. They also need to be able to manage growing hour-to-hour and seasonal variations in supply and demand. In the NZE Scenario, these needs are met by a broad portfolio of resources, including dispatchable low-emissions generation, battery storage, demand response and interconnections. Hydropower and nuclear are important sources of dispatchable low-emissions generation, while plants equipped with CCUS or using hydrogen or ammonia provide additional capacity. The role of thermal generation increasingly shifts from providing bulk electricity to supporting adequacy and flexibility during periods of system stress.

Battery storage plays a crucial role in providing short-term flexibility, and it sees the largest increase in installed capacity across all dispatchable sources. Installed battery storage capacity increased by 65% in 2025 to more than 290 GW, and it expands eleven-fold by 2035 in the NZE Scenario, reaching over 3 300 GW. Batteries increasingly provide short-term energy shifting, together with capacity and ancillary services, complementing other sources of flexibility such as demand response, hydropower, dispatchable generation and interconnections.

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Electricity grids expanded by about 30% over the past decade, adding about 20 million kilometres (km) of new lines, driven primarily by the increase in average and peak electricity demand. Grid deployment scales up rapidly in the NZE Scenario, with around 30 million km of new transmission and distribution lines added by 2035 to connect new sources, including solar PV and wind capacity that is often located at some distance from the existing grid. These new lines support the secure operation of increasingly complex power systems, including through highly digitalised networks, strengthened interconnections, grid-enhancing technologies and upgraded distribution networks. These features help grids to meet higher peak loads and enable more bidirectional power flows to manage changing consumption patterns.

The challenge extends beyond building new lines, since about 16 million km of existing lines across the world also need to be modernised by 2035. This requires investment in substations, interconnectors, digitalisation and system stability equipment. Some older lines that are approaching the end of their operational lifetimes need to be replaced rather than updated, particularly in advanced economies, where replacements are over 60% of total annual line additions to 2050, compared to one-third in emerging market and developing economies.

Timely delivery is particularly important because grid infrastructure can take considerably longer to plan, permit and construct than many of the technologies it needs to connect. Advanced-stage renewables in grid connection queues worldwide now total 3 000 GW, up 60% in a year, driven by battery storage and hybrid projects (IEA, 2026e). These queues underline the need for grid expansion to be backed by policy and regulatory frameworks that recognise its importance and support it – for example, by streamlining permitting. Without adequate grid expansion and modernisation, connection queues, congestion and curtailment could constrain both the deployment of new generation and electricity demand.

Scaling up low-emissions electricity sources across scenarios

Low-emissions power is already being deployed at speed, accounting for more than 70% of new installed capacity in 2025. Today's policy settings imply a modest acceleration of current growth in low-emissions power to 2030, increasing global renewables capacity to 2.6 times the 2022 level. This is progress towards, but still short of achieving, the COP28 objective of tripling global renewables capacity by 2030. The NZE Scenario sees faster progress and fully meets the goal of tripling renewables by this date. Deployment evolves differently across the two scenarios due to many factors, including differences in policy ambition, the pace of electrification (see next section) and energy security priorities.

The growth of solar PV and wind varies widely by scenario (Figure 6.9). Solar PV capacity grows rapidly to 2035 in all scenarios. Wind capacity additions also grow in all scenarios, reflecting the policy focus on both onshore and offshore wind in many markets. Deployment in the ARC is higher than in the Current Policies Scenario (CPS) and the STEPS, supported by countries' efforts to strengthen energy security by developing domestically available energy resources. Growth is strongest in the NZE Scenario, in which combined additions of solar PV and wind exceed 1 700 GW by 2035.

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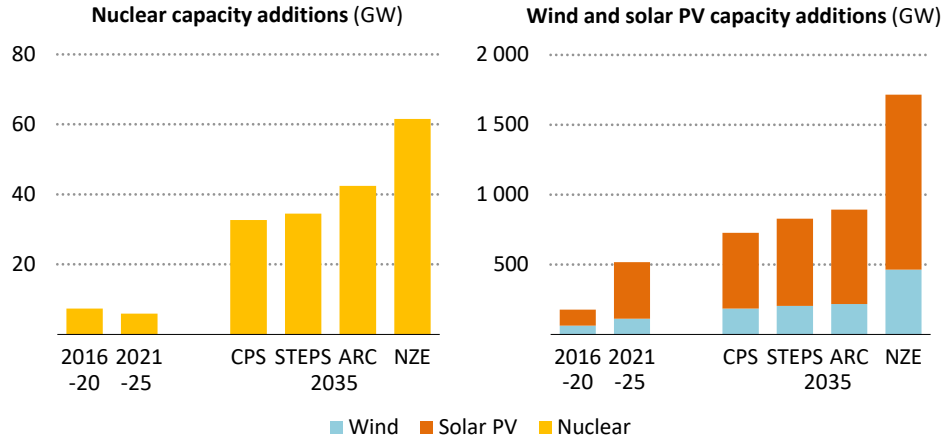
Figure 6.9 ▷ Average annual wind, solar PV and nuclear capacity additions by scenario, 2016-20, 2021-25 and 2035



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Low-emissions power capacity expansion continues through to 2035 in all scenarios; solar leads the way, wind progresses and nuclear regains momentum

Note: CPS = Current Policies Scenario; ARC = Additional Response Case; NZE = Net Zero Emissions by 2050 Scenario.

Nuclear capacity additions also increase in all scenarios. In the ARC, they grow strongly as countries increasingly look to nuclear as an option to strengthen energy security and reduce reliance on imported fossil fuels; in the NZE Scenario, they grow even more strongly. At COP28, more than 20 countries pledged to triple global nuclear power capacity by 2050, taking capacity to over 1 200 GW. The number of countries had increased to 38 as of August 2026. Reaching the tripling goal requires immediate efforts to scale up the nuclear industry in the late 2020s in order to accelerate deployment in the 2030s and beyond. In the NZE Scenario, annual deployment reaches around 60 GW by 2035, and by 2050, global nuclear capacity is nearly three times today's level.

Electricity grids and storage expansion across scenarios

Global battery storage additions rose from just over 1 GW in 2015 to around 115 GW in 2025, supported by sharply falling costs and growing flexibility needs. Grid expansion accelerates in all scenarios to 2035, driven by electrification and variable renewables (Figure 6.10). Grid build-out is broadly similar in the CPS, STEPS and ARC, reflecting comparable electricity demand growth, although higher renewable deployment raises grid expansion slightly in the ARC. Expansion is much faster in the NZE Scenario, in which rapid electrification and solar PV and wind deployment are supported by streamlined regulatory frameworks.

Average annual battery storage additions in the decade ahead range from 175 GW in the CPS to 330 GW in the NZE Scenario, putting the latter on track to achieve the COP29 pledge of

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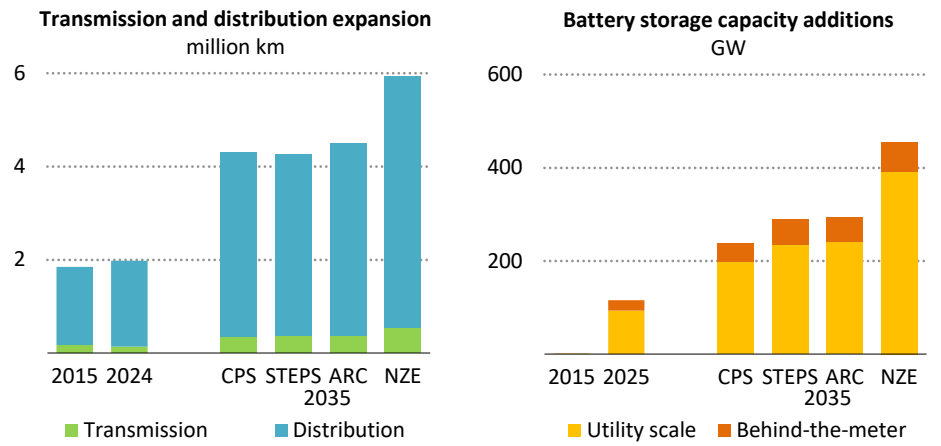
reaching 1 500 GW of global energy storage capacity by 2030. Batteries are increasingly moving beyond one-to-two-hour systems towards systems that provide power for four hours or more. Deployment is growing both behind the meter and at utility scale, including in hybrid systems co-located with renewables. By shifting electricity supply and demand across time and easing peak flows and congestion, batteries can also reduce the need for new grid capacity. Falling costs and short delivery times support continued growth across all scenarios.

Figure 6.10 ▷ Global transmission and distribution expansion and battery storage capacity additions by scenario, 2015-2035



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Transmission and distribution system expansion and battery storage capacity additions continue to rapidly increase in all scenarios

6.4.3 Electrification and efficiency

Beyond its role in reducing emissions, electrification is increasingly viewed by fuel-importing countries as a key means of strengthening energy security, reducing exposure to volatile international fuel markets and making greater use of domestic energy resources. These considerations have gained additional prominence following the 2026 energy crisis and disruptions linked to the Strait of Hormuz. In this context, the COP31 Presidency requested that the IEA develop a special report on electrification looking at how to increase electricity's share of total final energy consumption from 23% in 2025 to 35% by 2035 (IEA, 2026b). The NZE Scenario meets this objective. The pace and extent of electrification vary across regions and sectors, reflecting differences in starting points, energy service needs and economic potential (Figure 6.11).

Energy and material efficiency improvements in end-uses are critical to the NZE Scenario, and electrification plays an important role in improving energy efficiency because many electric technologies are substantially more efficient than the alternatives they replace.

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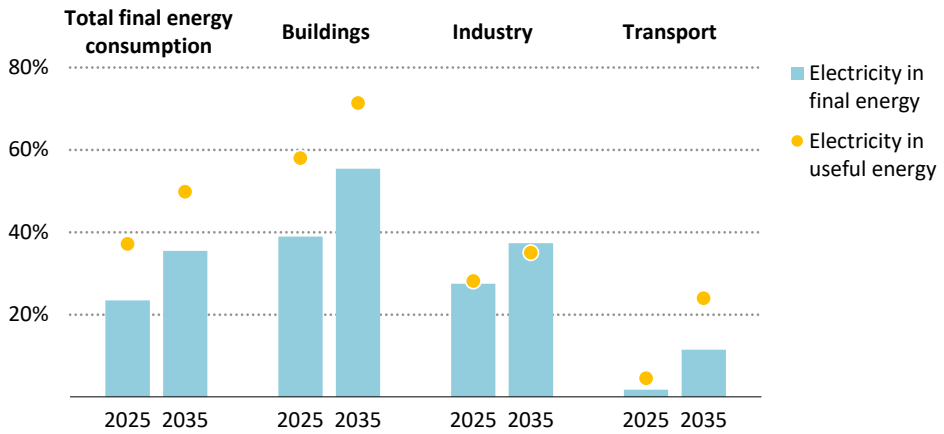
Improvements are achieved through a range of measures, including the deployment of electric technologies such as electric vehicles and heat pumps, the uptake of more efficient equipment through strengthened minimum energy performance standards (MEPS), further efficiency gains in conventional vehicles, and increased levels of recycling, building retrofits and access to modern forms of energy, notably for cooking.

Figure 6.11 ▻ Share of electricity in final energy and useful energy for end-use sectors in the NZE Scenario, 2025 and 2035



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The share of electricity in final energy consumption reaches about 35% by 2035 in the NZE Scenario, with rapid acceleration in the transport sector

Road transport electrification

Electric vehicles (i.e. battery electric or plug-in hybrid vehicles) are already cost-competitive in many key markets today, and IEA analysis shows that half of oil-based road transport could be electrified competitively in 2025 (IEA, 2026b). In 2025, one in four cars sold globally was electric, and 15% of two/three-wheelers and around 10% of heavy-duty trucks sold had electric powertrains, with most sales of all these vehicle types concentrated in China, Europe and Southeast Asia. The EV market expanded further geographically in the first half of 2026, due in part to high oil prices resulting from the 2026 energy crisis.

The road transport sector is currently much less electrified than the buildings and industry sectors, but its electrification rate rises in the NZE Scenario from 1% today to around 15% by 2035 as widespread policy support, faster technology innovation and accelerated charging infrastructure deployment continue to increase EV competitiveness across the globe. Greater electrification in the major car-exporting markets across advanced economies and China also contributes by increasing the flow of used EV exports to other emerging market and developing economies. This flow rises from fewer than 50 000 in 2025 to around 1 million in 2035. The number of electrified light-duty vehicles – which include passenger

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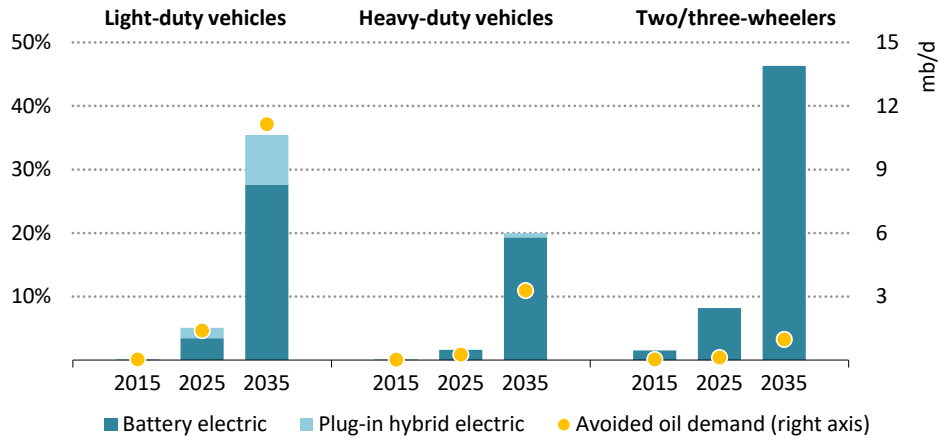
cars and light commercial vehicles – increases from 80 million to 650 million by 2035 in the NZE Scenario, helping the world to avoid more than 10 million barrels per day (mb/d) of oil demand (Figure 6.12).

Figure 6.12 ▷ Electric vehicle share in total global stock and avoided oil demand by vehicle type in the NZE Scenario, 2015-2035



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The electrification of all vehicle types increases in the NZE Scenario, displacing 15 mb/d of oil demand in 2035

Notes: mb/d = million barrels of oil per day; EV = electric vehicle. Light-duty vehicles include passenger cars and light commercial vehicles. Heavy-duty vehicles include buses, medium freight trucks and heavy freight trucks.

Electrification makes rapid strides in other road transport modes too. The stock of electric heavy-duty vehicles rises more than 13 times to 25 million units, and by 2035, it accounts for 20% of the global total, up from just 2% in 2025. The stock of electric two/three-wheelers rises to over 45% of the global total by the same date. In the NZE Scenario, the further electrification of medium and heavy freight trucks, two/three-wheelers and buses together helps the world to avoid nearly 5 mb/d of oil demand by 2035.

As transport electrification progresses, EVs become a major source of electricity demand growth. Electricity demand from road transport increases from 235 terawatt-hours (TWh) today to nearly 3 000 TWh by 2035 in the NZE Scenario, while road transport sector emissions decline by 35% to 4.2 Gt CO_2 as EVs avoid 2.6 Gt CO_2.

Buildings electrification

Space heating today accounts for 34% of buildings energy consumption. Electricity met 13% of space heating demand in 2025, up three percentage points from 2015, following rising sales of heat pumps and other electric technologies. Heat pump sales have increased by almost 30% since 2019, but trends have been uneven in recent years. In 2025, global sales

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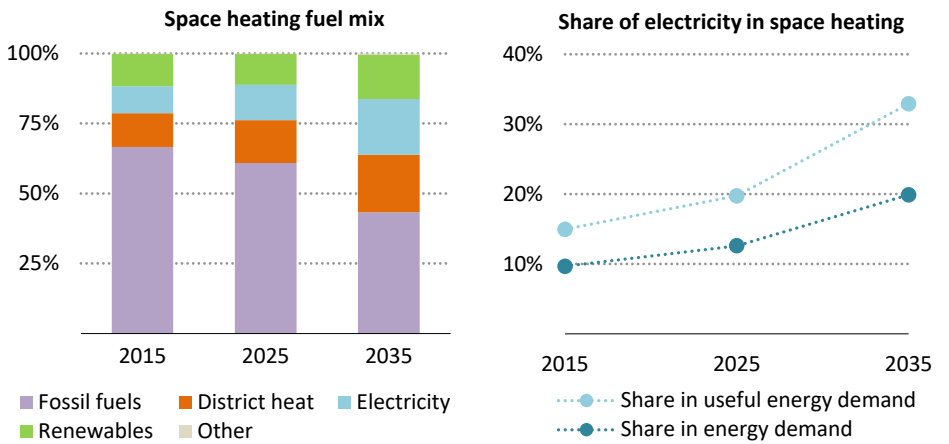
dipped slightly (IEA, 2026f), but sales in the European Union grew by 12%, the strongest annual growth since the 2022 energy crisis, and heat pumps were the first choice of heating technologies in markets such as Germany and the United States (IEA, 2026g). IEA analysis finds that more than half of global space heating demand could be electrified competitively in 2025 (IEA, 2026b).

Figure 6.13 ▷ Space heating fuel mix, and share of electricity in useful energy demand in the NZE Scenario, 2015-2035



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Electricity's share in useful space heating energy demand rises to 33% by 2035, displacing fossil fuel consumption

Note: Other includes hydrogen and non-renewable waste.

In the NZE Scenario, electricity demand for space heating grows by nearly 400 TWh by 2035. In regions with high heating needs, notably in advanced economies and China, this increase reflects the rapid deployment of heat pumps, which also brings substantial efficiency gains. The efficiency of electric heating technologies means they provide more units of heat per unit of consumption than fossil fuel alternatives. As a result, electricity's share in useful energy demand for space heating (33% by 2035, up from 20% today) is higher than its share in final energy consumption (20% in 2035, up from 13% today) (Figure 6.13). By 2035, global heat pump sales reach almost 400 GW, compared with 110 GW in 2025. This transformation leads fossil fuel consumption in space heating to fall steeply and almost halve by 2035. This decline, led by natural gas, brings the share of fossil fuel in the space heating fuel mix below 45% by 2035.

In regions with limited heating needs, water heating and cooking are the main drivers of the electrification of the buildings sector. At the global level, electricity use rises to account for around one-third of energy consumption for both water heating and cooking by 2035. In addition to this increasing adoption of electric technologies for space heating, water heating

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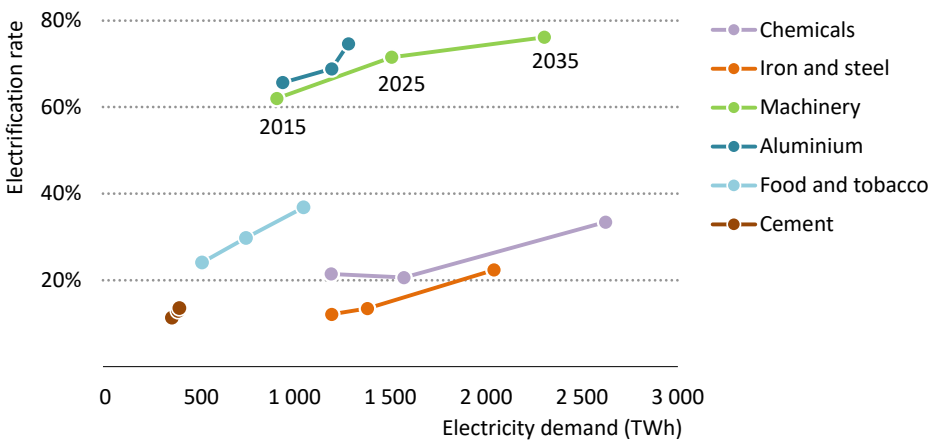
and cooking, electricity demand growth in the buildings sector is led by rising demand for electricity-based services such as cooling and appliances. As a result, about 350 TWh of buildings electricity demand is added on average each year to 2035, bringing the sector's electrification rate to 55%. Over the same period, gains in equipment efficiency and envelope performance moderate the sector's energy demand and help reduce direct CO_2 emissions by around 40% to 1 800 million tonnes of carbon dioxide (Mt CO_2) by 2035.

Industry electrification

Due to the wide variety of industrial processes, the potential to electrify industry varies significantly by application. Low- and medium-temperature heat accounts for nearly 90% of heat demand in non-energy-intensive industries, and substantial opportunities exist to electrify with technologies such as heat pumps and electric boilers that are already commercially competitive in many regions. Our analysis shows that around 40% of energy consumption in low- and medium-temperature applications in industry could be electrified cost-effectively in 2025 (IEA, 2026b). In the NZE Scenario, electricity's share of industrial energy consumption rises from 27% in 2025 to around 40% by 2035, reaching nearly 50% in non-energy-intensive industries and 30% in energy-intensive industries (Figure 6.14). Heat pump deployment in non-energy-intensive industries grows tenfold over the next decade.

Figure 6.14 ▷ Electricity demand and electrification rate for selected industrial sub-sectors in the NZE Scenario, 2015-2035



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Electricity's share of industrial energy consumption in the NZE Scenario rises from 27% today to around 40% in 2035, resulting in nearly 4 500 TWh of additional electricity demand

Nevertheless, technical and economic constraints limit the scope for electrification in energy-intensive industries, particularly for high-temperature processes. In the chemicals sector, electric boilers are increasingly used to supply steam. By 2035, 7 million tonnes (Mt) of electrolytic hydrogen are used to produce low-emissions methanol and ammonia in the

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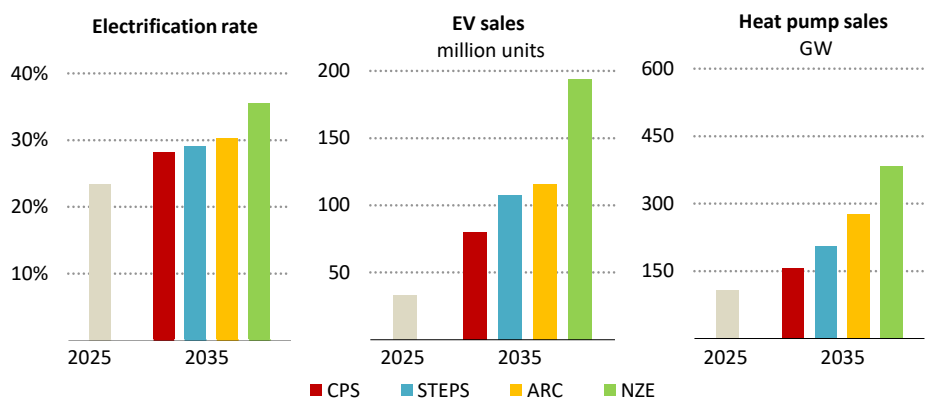
NZE Scenario, with roughly 10% of primary chemicals production coming from electrolytic hydrogen-based routes. Electrifying higher-temperature processes such as steam cracking remains technically challenging and is not yet economically competitive. In the iron and steel sector, electrification continues to advance in both iron making and steel making. In the NZE Scenario, 9 Mt of electrolytic hydrogen produced on site are used to supply more than 10% of global iron demand by 2035, and electric arc furnace steel production nearly doubles over the same period. Even in the NZE Scenario, however, more than half of steel production in 2035 continues to rely on the blast furnace-basic oxygen furnace route. The use of electric kilns in cement production remains marginal in economic terms in 2035.

Electricity demand in industry increases from 11 500 in 2025 to nearly 16 000 TWh by 2035 in the NZE Scenario. Alternative low-emissions fuels, such as hydrogen and hydrogen-based fuels, play an essential complementary role alongside electricity in reducing industry sector emissions on the pathway to net zero emissions by 2050, as do carbon capture technologies.

Electrification across IEA scenarios

The electrification rate rises in all IEA scenarios, and the differences between them in 2035 are relatively small, except in the NZE Scenario (Figure 6.15). In the CPS, it rises from 23% in 2025 to 28% in 2035; in the STEPS, it reaches 29%; and in the ARC, it touches 30%. The major driver of the increase in the electrification rate is the strong growth in the share of electricity in transport energy consumption, which is a trend common to all scenarios. The NZE Scenario sees stronger growth in the share of electricity in the transport sector than the other scenarios. It also sees electrification expanding more to new end-uses and sectors. In addition, the stronger focus on energy efficiency in the NZE Scenario supports a higher electrification rate by lowering total energy consumption.

Figure 6.15 ▷ Electrification indicators by scenario, 2025 and 2035



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Electrification rates rise across all IEA scenarios, increasing by 5-7 percentage points to 2035 in scenarios building on today's policies, and to 35% in the NZE Scenario

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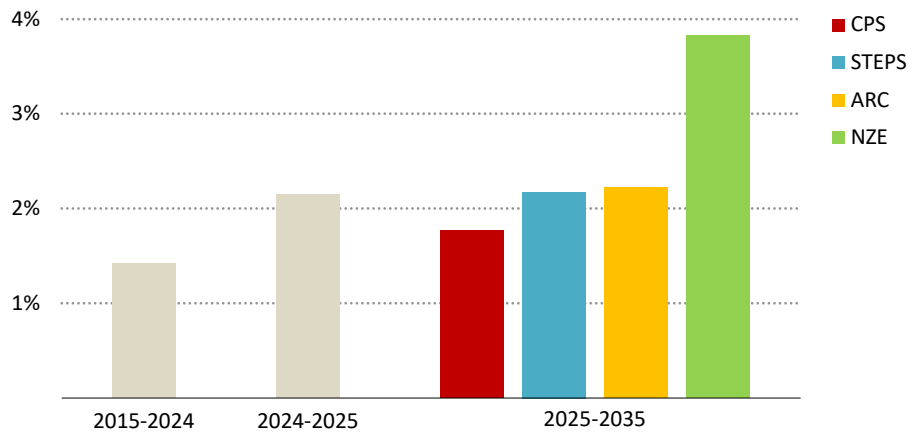
Energy efficiency

The most comprehensive measure of energy efficiency at the global level is the energy input per unit of economic output, also known as energy intensity. In 2025, energy intensity improved by more than 2% globally, which was higher than the average of 1.5% over the previous decade (Figure 6.16). In the NZE Scenario, the rate of energy intensity improvement doubles by 2030. This leads global energy demand in 2030 to fall 2% below its level today, even though global GDP grows by around 14%. Achieving these gains requires a comprehensive range of measures, including improvements in technical efficiency, switching to more efficient fuels and technologies, and expanded access to clean cooking, alongside structural changes driven by modal shifts and material efficiency.

Figure 6.16 ▷ Average annual energy intensity improvement by scenario, 2015-2035



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In the NZE Scenario, annual efficiency gains more than double in the next decade compared to the previous decade

The energy required to generate a unit of electricity declines as the power mix shifts towards renewables and the efficiency of the thermal fleet improves. In 2025, generating 1 TWh of electricity required around 7.7 petajoules of energy inputs. By 2035, this falls by around 15% in the STEPS and by over one-quarter in the NZE Scenario.

In the NZE Scenario, building energy codes are aligned with zero-carbon-ready building standards in all countries by 2035, while the annual retrofit rate rises above 2% in advanced economies. In emerging market and developing economies, improvements in the efficiency of new buildings are particularly important as floorspace expands rapidly, while MEPS for appliances and air conditioners help limit energy demand growth even as equipment ownership increases. In advanced economies, a large share of efficiency gains stem from accelerated uptake of heat pumps for space heating. In sub-Saharan Africa, expanded access

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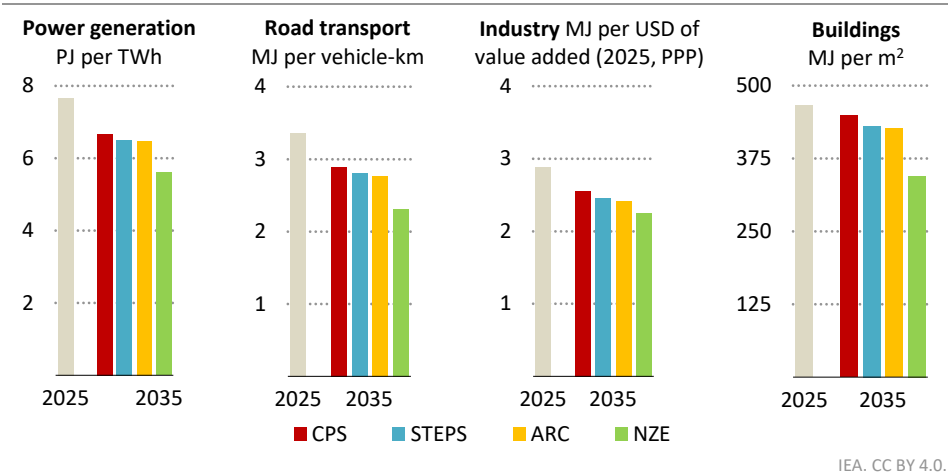
to clean cooking delivers around three-quarters of the efficiency gains in the next decade, as 900 million people gain access to clean cooking solutions by 2035, shifting away from inefficient traditional use of biomass. Energy intensity in the buildings sector declines by more than 25% by 2035 in the NZE Scenario (Figure 6.17).

Figure 6.17 ▷ Energy intensity by sector and scenario, 2025-2035



Energy intensity is reduced by more than 20% in all sectors by 2035 in the NZE Scenario

Note: PJ = petajoule; MJ = megajoule.

Improvements in industrial equipment and processes, including electric motors, together with material efficiency measures that reduce demand for energy-intensive materials, bring industry energy intensity down by 22% by 2035 in the NZE Scenario. Resource efficiency in major industrial value chains reduces industry sector emissions by around 700 Mt CO_2 in 2035, equivalent to 7% of today's total. Increased recycling of plastics also reduces energy demand, displacing almost 1 mb/d of oil demand by 2035 relative to the STEPS.

In the NZE Scenario, road transport energy intensity falls by roughly a third by 2035, as electric vehicles account for the majority of new vehicle sales, and fuel economy continues to improve across all types of drivetrains. Meanwhile, accelerated investment in technology and infrastructure enables further efficiency gains from modal shifts, notably through greater use of public transport.

6.4.4 Low-emissions fuels

While electrification provides the largest share of emissions reductions in end-uses in the NZE Scenario, low-emissions fuels remain essential where direct electrification is technically difficult or prohibitively expensive. Modern bioenergy, low-emissions hydrogen and hydrogen-based fuels increasingly complement electricity, accounting for more than 10% of total final consumption in 2035 and nearly 20% in 2050, up from 5% today. Meeting this

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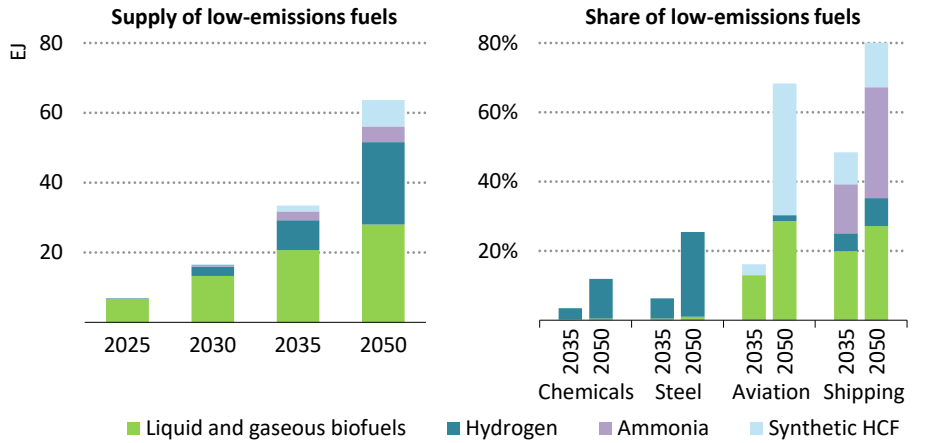
demand requires a rapid scaling up of supply, with low-emissions fuel production nearly quintupling by 2035 and exceeding 60 exajoules (EJ) by 2050 (Figure 6.18).

Figure 6.18 ▷ Low-emissions fuels supply by fuel to 2050 and use in selected sub-sectors in the NZE Scenario, 2035 and 2050



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Low-emissions fuel use nearly quintuples by 2035 and continues to grow thereafter, exceeding 60 EJ by 2050 as deployment expands in hard-to-electrify sectors

Notes: HCF = hydrocarbon fuels. The share of low-emissions fuels refers to the share of these fuels in energy consumption in the sub-sector. For chemicals and steel, the total energy consumption includes the energy use for onsite low-emissions hydrogen production. Estimates exclude solid modern bioenergy.

Aviation and shipping drive most of the growth in low-emissions fuels use in the transport sector. Sustainable aviation fuels (SAF) provide the main route to reduce aviation emissions in the next decade, with biofuels meeting around 80% of SAF demand in 2035, while synthetic fuels become increasingly important towards 2050 (Box 6.3). In shipping, the use of low-emissions ammonia, hydrogen, biodiesel, biomethane, and bio- and synthetic methanol grows rapidly, with these fuels collectively providing more than 45% of shipping energy demand by 2035 and around 80% by 2050.

Box 6.3 ▷ Sustainable aviation fuel offers wider energy security benefits in the NZE Scenario

Air transport accounts for less than 1% of global trade by volume, but around one-third by value, underpinning tourism, business travel and the movement of high-value goods (IATA, 2026a). Almost all aviation activity relies on conventional jet fuel (Figure 6.19). In 2025, the sector consumed over 7 mb/d, equivalent to 7% of global oil demand. Airline fuel expenditure is expected to jump from USD 252 billion in 2025 to USD 350 billion in 2026, highlighting the effects of the 2026 energy crisis on the price of jet fuel and the vulnerability that comes from the sector's reliance on a single fuel (IATA, 2026b).

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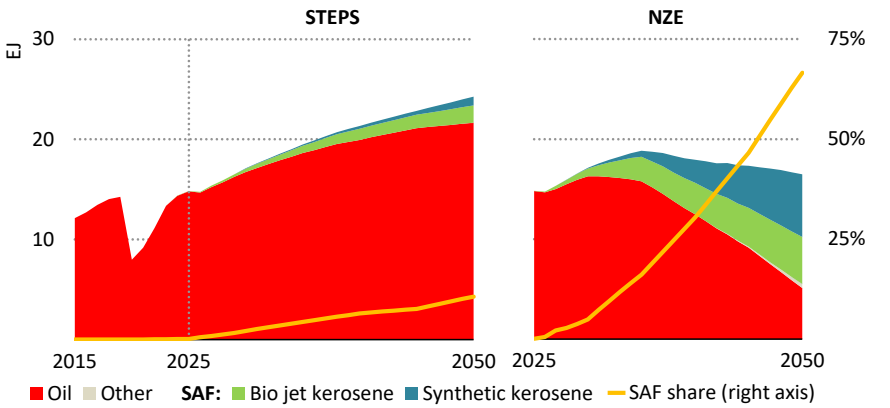
Figure 6.19 ▷ Aviation energy demand by fuel and scenario, 2015-2050



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SAF supplies 10% of aviation fuel by 2050 in the STEPS, up from less than 1% today, but stronger policy support is needed to reach the levels achieved in the NZE Scenario

Notes: SAF = sustainable aviation fuels. Other includes hydrogen and electricity.

SAF remains the only viable alternative to conventional jet fuel, but it accounts for less than 1% of global aviation fuel use because it costs between three and ten times more to produce than conventional jet fuel. The European Union's SAF mandate, which obliges airlines to use 20% SAF in their aviation fuel mix by 2035, is expected to increase average ticket prices by around 10% in 2035, taking account of the likely decline in SAF production costs over time (IEA, 2026h). SAF mandates, incentives and targets are being introduced in a growing number of countries, though with varying levels of ambition. In the STEPS, the use of SAF grows from less than 1% today to nearly 5% of aviation fuel demand by 2035 and about 10% by 2050, with SAF derived mainly from biofuels in Brazil, China, Europe, Japan, Korea and North America. In the NZE Scenario, SAF supplies over 65% of aviation fuel by 2050, with 57% coming from synthetic kerosene. Diversifying fuel sources through bio-based and synthetic production pathways, drawing on domestic biomass and renewable electricity, would diversify aviation's energy mix, reduce reliance on conventional kerosene, limit exposure to oil price volatility and import dependence, and strengthen aviation energy security.

Government policy has a central part to play in accelerating SAF deployment through mandates and incentives that support domestic production, diversify fuel to reduce oil imports, diversify aviation fuel supplies and cut emissions. Efficiency gains and a shift to rail on short-haul routes would help to reduce aviation fuel consumption in parallel.

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Industry is another major source of sustainable fuel demand. In the NZE Scenario, low-emissions hydrogen increasingly replaces fossil fuel-based hydrogen in existing uses such as the production of chemicals, while opening new decarbonisation pathways for steel and other energy-intensive industries. By 2035, more than one-third of industrial hydrogen demand is met by low-emissions sources. Modern bioenergy also supports industrial decarbonisation, particularly where high-temperature heat requirements limit the scope for direct electrification. In buildings, biomethane plays a complementary role alongside electrification, providing an alternative to heat pumps for applications that remain connected to gas networks or for which electrification is more costly. Biomethane is increasingly used in emerging market and developing economies, where it helps countries reduce emissions while they continue to use existing gas infrastructure.

Biofuels

Biofuels depend on land use for their production, and increased use of biofuels is constrained by competing land uses such as food production and forest conservation. Total primary bioenergy and waste consumption in the NZE Scenario is just over 100 EJ in 2050, which is approximately equivalent to conservative estimates for the sustainable global production potential of bioenergy (Creutzig et al., 2014).

In contrast with current production, which relies mainly on constrained supplies of food crops and waste vegetable oil, the NZE Scenario sees increasing amounts of liquid biofuels produced from short-rotation woody biomass crops. These crops can be grown on marginal land but still produce twice as much bioenergy per hectare as existing bioenergy crops. Woody biomass is also used as solid bioenergy with minimal processing in several sectors, particularly electricity generation, energy-intensive industries and space heating. Converting these crops into drop-in liquid fuels requires advanced technologies, and the NZE Scenario sees production of these fuels rise from low levels today to nearly 1.5 EJ by 2035.

Hydrogen and hydrogen-based fuels

The energy sector consumed more than 100 Mt of hydrogen in 2025 – mostly in industry (56%) for ammonia and methanol production, and in refining (43%) for hydrocracking and desulphurisation processes. Supply remains almost entirely based on unabated fossil fuels, with low-emissions hydrogen meeting less than 1% of global demand.

Low-emissions hydrogen production scales up rapidly in the NZE Scenario, reaching 30 Mt by 2030. This is broadly in line with the announced project pipeline for production. However, only 15% of these projects, in terms of production volume, are either operational or have reached a final investment decision, and more than 45% have uncertain prospects of becoming operational by 2030 (IEA, 2026i). In the NZE Scenario, low-emissions hydrogen production expands to meet over 60% of total hydrogen demand by 2035 and over 90% by 2050. Early growth is driven by efforts to replace hydrogen produced from unabated fossil fuels in industry and refining. As deployment expands, new demand from transport and

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power generation emerges, increasing total hydrogen demand by around 80% by 2035 and more than tripling it by 2050.

6.4.5 Carbon capture, utilisation and storage

Carbon capture, utilisation and storage (CCUS) has an essential part to play in helping the energy sector to reach net zero emissions by 2050. It enables emissions to be tackled in hard-to-abate sectors, such as cement production, for which alternatives are limited, and it can support the direct removal of CO_2 from the atmosphere. In the NZE Scenario, CO_2 emissions captured annually grow rapidly over the next decade to 2.2 Gt CO_2 by 2035, before scaling up to 3.9 Gt CO_2 in 2040 and 6.4 Gt CO_2 by 2050.

More than a quarter of the emissions captured in the NZE Scenario by 2035 come from the industry sector. The production of cement and clinker accounts for the largest share of the total, reflecting the lack of alternative low-emissions methods. Other emissions are captured from the production of iron and steel and primary chemicals. Although less than 1% of global power generation capacity uses fossil fuels combined with CCUS technology by 2050 in the NZE Scenario, the size of the power sector means that electricity production nevertheless accounts for an important volume of captured emissions, with up to 1 Gt CO_2 captured annually by 2050. About half of the emissions captured in the power sector come from coal use for electricity generation.

Hydrogen and ammonia production account for more than 300 Mt CO_2 captured annually by 2035 and close to 670 Mt by 2050. CCUS enables alternative fuel production to scale up rapidly in the NZE Scenario, making it possible to move away from current fossil fuel-based hydrogen and hydrogen-based fuels.

CCUS also plays an important part in the decarbonisation of the oil and natural gas industry in the NZE Scenario. About 105 Mt of CO_2 are captured in 2030 from extraction sites, and the level of captured CO_2 emissions falls over the following two decades as demand for oil and natural gas declines sharply. By 2040, all CO_2 emissions from oil and natural gas production are captured.

Direct air capture and storage (DACS) and bioenergy with carbon capture and storage (BECCS) are equally essential. Annual CO_2 removals reach 2.7 Gt by 2050 and 4 Gt by 2100 in the NZE Scenario. These removals help average temperatures return to below 1.5 °C by the end of the century. The amount of CO_2 removal through DACS and BECCS has increased in this year's *World Energy Outlook* (about 30% by 2050) to compensate for the rise in emissions in 2025 and the higher overshoot that results. This level of geological removals remains at the low end of those in IPCC scenarios compatible with the Paris Agreement goal, including the new set of scenarios under the seventh phase of the Coupled Model Intercomparison Project (CMIP7) (Box 6.4).

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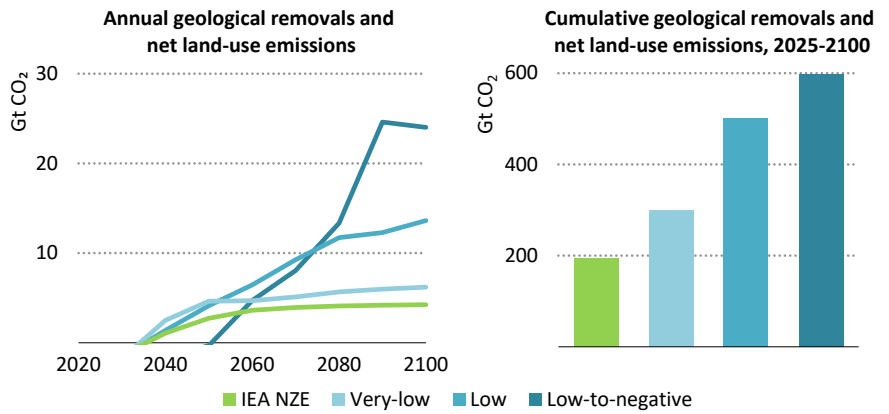
Box 6.4 ▻ How do carbon removals in the NZE Scenario compare with CMIP7 scenarios?

In 2026, seven new CMIP7 scenarios were released to drive model simulations for the IPCC's Seventh Assessment Report (Van Vuuren et al., 2026). Three scenarios provide Paris Agreement-compatible pathways: the "low emissions" scenario limits global warming to below 2 °C without returning to 1.5 °C by the end of the century; the "very low emissions" scenario is designed to keep the temperature level as low as plausible with limited overshoot; and the "low-to-negative emissions" scenario implies a high overshoot before returning to 1.5 °C by the end of the century.

Figure 6.20 ▻ Geological removals and net land-use emissions in selected CMIP7 scenarios and the IEA NZE Scenario, 2025-2100



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The IEA NZE Scenario is at the low end of current CMIP7 scenarios that keep temperature rise below 2 °C by the end of the century

Note: Net carbon removals include geological removals (BECCS and DACS) and net land-use CO_2 emissions.
Source: IEA analysis based on IIASA (2026).

The extent of the role played by geological removals (BECCS and DACS) varies between scenarios (Figure 6.20). In the very low emissions scenario, CO_2 emissions are reduced very rapidly, which means BECCS and DACS are needed to remove only 1.5 Gt by 2100. In the low emissions scenario, emissions are reduced less rapidly, but still fast enough to keep the rise in temperature below 2 °C by the end of the century. BECCS and DACS reach 8.4 Gt by 2100 in this scenario. In the low-to-negative emissions scenario, the overshoot is larger, and limiting the temperature rise to 1.5 °C by 2100 requires deployment of BECCS and DACS on a wider scale. In this scenario, the use of BECCS and DACS increases rapidly from 2050 to reach more than 20 Gt CO_2 annually by 2100, almost three times the level required in the low emissions scenario.

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The contribution of geological removals in the IEA's NZE Scenario is vital, but it remains limited because of the strength of the mitigation efforts made in the near term. Reducing dependence on removal technologies that remain unproven at scale requires immediate action to limit peak warming, including faster cuts in short-lived climate pollutants[5] and the rapid deployment of low-emissions technologies across the energy system. In the NZE Scenario, BECCS and DACS remove about 210 Gt in aggregate by the end of the century, putting the NZE Scenario at the low end of current IPCC CMIP7 scenarios. Similarly, land-use sinks remain minimal in the NZE Scenario: cumulative net land-use CO_2 emissions to 2100 are positive, at 16 Gt, while most CMIP7 scenarios consider land-use sectors as net sinks, obtaining up to a cumulative -260 Gt net land-use emissions in the low emissions scenario. Taken together, geological storage and net land-use emissions in the NZE Scenario represent a cumulative 195 Gt CO_2 removed by 2100.

6.5 Emissions and climate outcomes

6.5.1 Emissions trends

CO_2 emissions

In the NZE Scenario, co-ordinated global action to limit the rise in global average temperatures to 1.5 °C results in deep energy-related emissions cuts in the short term; by 2035, CO_2 emissions from the energy sector are more than halved to less than 19 Gt (Figure 6.21). The decline in coal-fired generation is the leading driver of emissions reductions in the NZE Scenario over the next decade, contributing nearly 8 Gt CO_2 reductions in 2035 and accounting for roughly 40% of total CO_2 reductions by this date. These reductions are made possible by a 28 000 TWh increase in generation from renewables and nuclear, bringing their combined generation to more than three times today's levels. In addition, the transport sector reduces CO_2 emissions by 3 Gt over the same period, mostly as a result of the accelerated deployment of electric vehicles. The industry sector contributes around 2.5 Gt of CO_2 emissions reductions through a combination of electrification, low-emissions hydrogen use, energy efficiency, deployment of carbon capture and storage, and more innovative processes for producing industrial materials. The buildings sector contributes over 1 Gt CO_2 of further emissions reductions as the share of useful energy for space heating supplied by electricity increases from 20% today to 33% in 2035.

[5] Short-lived climate pollutants include aerosols (or particulate matter) and chemically reactive gases such as methane and nitrogen oxides.

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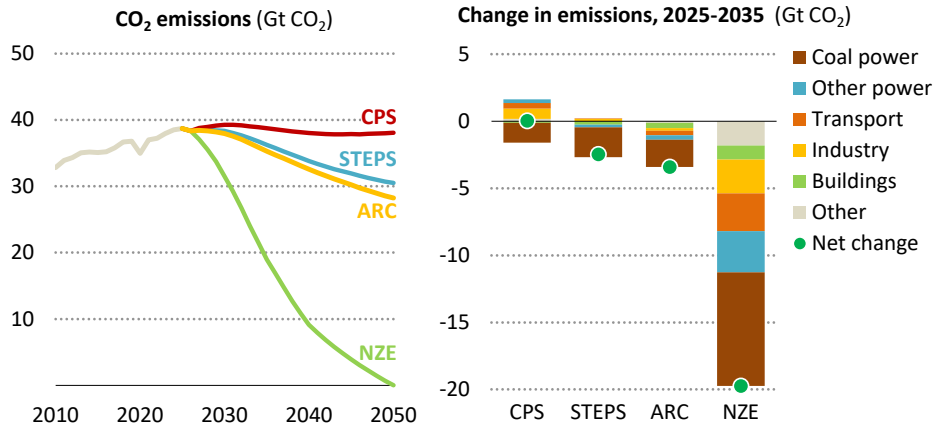
Figure 6.21 ▷ Global energy-related CO_2 emissions by scenario, 2010-2050, and change in CO_2 emissions by sector and scenario, 2025-2035



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Energy-related CO_2 emissions fall rapidly in the NZE Scenario, led by reductions in coal-fired power generation

Notes: CO_2 = carbon dioxide. Other power includes generation from natural gas, oil, hydrogen, bioenergy, nuclear and other renewables. Other includes emissions from agriculture and other energy sector.

Methane emissions

The production, transport and use of fossil fuels account for around 35% of human-linked emissions of methane, which is the second-largest contributor to climate change after carbon dioxide. Although it lingers in the atmosphere for far less time (12 years on average, compared with centuries for CO_2), methane absorbs substantially more heat energy while it is there. Rapid and sustained reductions in methane emissions have a crucial part to play in limiting near-term global warming and improving air quality.

In the NZE Scenario, energy sector methane emissions drop sharply as countries and companies mobilise to meet targets for zero routine flaring and methane abatement by 2030 (Figure 6.22). By 2035, annual methane emissions fall by around 75% from current levels to around 1.2 Gt CO_2-eq, led by a 70% reduction in the global average methane intensity of upstream oil and gas production (from 0.19 kg CH_4 per gigajoule (GJ) in 2025 to 0.06 in 2035) and a 50% reduction in the upstream intensity of coal. Emissions reductions come primarily from abatement in the oil and gas industry (60%), coal mines (30%) and end-use combustion (10%), the last driven by rapid improvements in access to clean cooking fuels.

Current and stated policies fall far short of the emissions reductions in the NZE Scenario. In the CPS, methane emissions decrease slightly in the short term but plateau at current levels to 2050, reflecting a rise in demand for fossil fuels, the absence of voluntary action by companies, and limited implementation of methane policies and regulations. In the STEPS and ARC, full implementation of the policies currently enacted or under development reduces fossil fuel methane emissions by around 25% by 2035 and around 40% by 2050.

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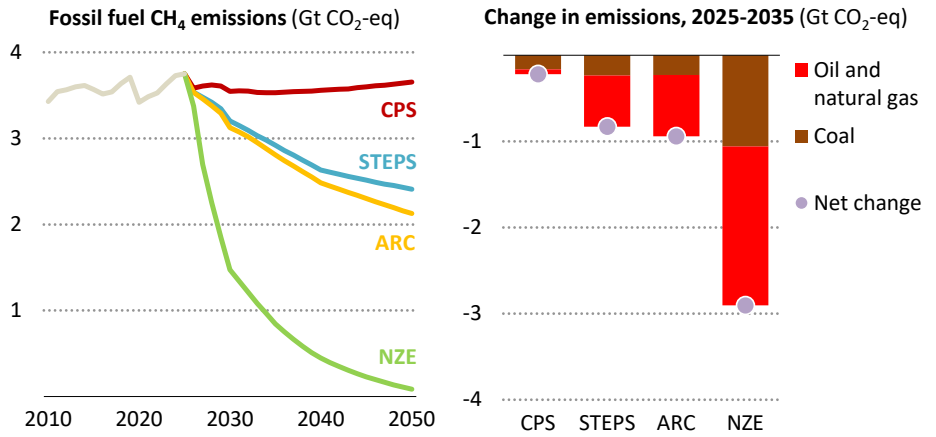
Figure 6.22 ▷ Global fossil fuel methane emissions by scenario, 2010-2050, and change in methane emissions by fuel and scenario, 2025-2035



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Fossil fuel methane emissions decrease in STEPS and ARC, but the reduction falls far short of what is needed in the NZE Scenario

Note: Fossil fuel methane emissions include methane emissions associated with upstream and downstream coal, oil and gas production activities.

6.5.2 Air pollution

In 2025, air pollution remained one of the leading environmental risks to human health, causing 17 000 premature deaths per day. This is more than five times the number of deaths caused by road accidents, and more than twice the average annual number of deaths from Covid-19 reported during 2020-2021 (WHO, 2026; Msemburi et al., 2022). Pollution-related diseases also impose a substantial economic burden through increased healthcare costs, lower labour productivity and premature mortality. Recent evidence shows that air pollution directly lowers labour productivity (OECD, 2025b). The economic damage associated with ambient air pollution is estimated at between USD 4.5 trillion and USD 6.1 trillion annually, equivalent to between 4.7% and 6.5% of global GDP, with the largest impacts in emerging market and developing economies (World Bank, 2025). In countries where air pollution reaches extreme levels, the costs can be much higher.

Air pollutant emissions from energy-related sources are primarily driven by the combustion[6] of fossil fuels and solid bioenergy. The NZE Scenario delivers rapid reductions in air pollutant emissions across regions and sectors. Faster deployment of low-emissions electricity, electrification and improvements in energy efficiency reduce emissions from power generation, industry and transport, while addressing the lack of access to clean cooking

[6] Air pollutant emissions include sulphur dioxide (SO_2), nitrogen oxides (NO_x) and fine particulate matter ($PM_{2.5}$).

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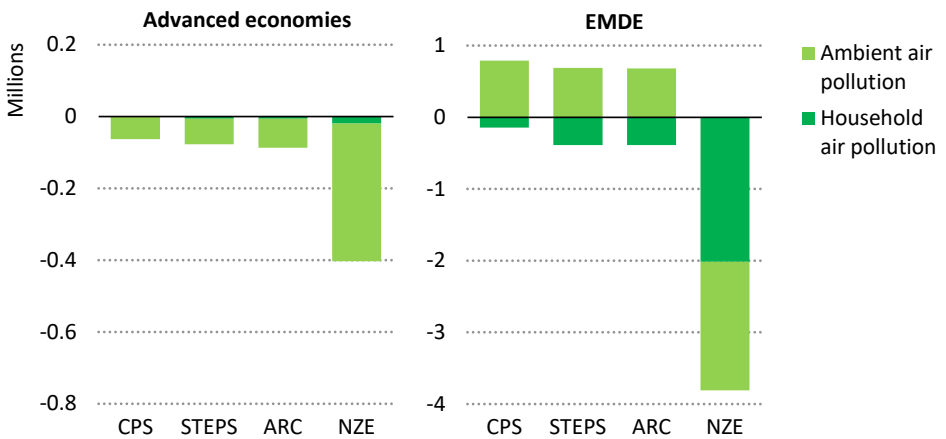
sharply reduces pollution from residential energy use. These reductions are sufficient to overcome pressures from population growth, urbanisation and ageing populations, and they lead to lower exposure to air pollution and fewer premature deaths by 2035 (Figure 6.23). Exposure to heavily polluted air falls by around 80% by 2035, delivering substantial health benefits (Box 6.5).

Figure 6.23 ▷ Change in annual premature deaths from ambient and household air pollution by scenario, 2025-2035



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Premature deaths from ambient air pollution continue to rise in EMDE in the CPS, STEPS and ARC, but the accelerated energy transition in the NZE Scenario reverses the trend

Note: EMDE = emerging market and developing economies.

The health benefits are particularly large for household air pollution. Around 2.5 million annual premature deaths are associated with household air pollution today. In the NZE Scenario, these fall from 2025 levels by around 80% to 450 000, driven by substantial progress in expanding access to clean cooking. The benefits extend beyond household pollution: the rapid reductions in emissions from power generation, industry and transport also lower exposure to ambient air pollution and cut the number of premature deaths associated with it, particularly in emerging market and developing economies.

The gap with the other WEO scenarios illustrates the scale of additional action required to translate declining emissions into better health outcomes. In the CPS, total global pollutant emissions fall by around 10% between 2025 and 2035. Declining coal use in power generation and the replacement of older vehicles reduce air pollutant emissions in advanced economies and China, but emissions increase or decrease only marginally in other regions due to continued fossil fuel use and slow progress on clean cooking. The STEPS and ARC see similar trends in many regions, but total global pollutant emissions in these scenarios decline by more than in the CPS, falling 15% by 2035. A reduction in pollutant emissions does not

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automatically translate into lower mortality, since population growth, urbanisation and ageing can increase the number of people exposed and vulnerable to air pollution. Annual premature deaths from ambient air pollution rise to 5.5 million by 2035 in the CPS and to 5.4 million in both the STEPS and ARC, with Africa and developing Asia together accounting for almost all the increase.

Box 6.5 ▷ Short-lived climate pollutants: near-term climate action for long-term co-benefits

Short-lived climate pollutants (SLCPs), including methane, black carbon, tropospheric ozone and some fluorinated gases, are major contributors to global warming. Despite their short atmospheric lifetimes, they have a strong warming effect, making them an important target for near-term action. Their rapid reduction is particularly important for limiting peak warming and therefore the magnitude and duration of any temporary overshoot of 1.5 °C. While deep reductions in CO_2 emissions are essential to limit long-term warming, cutting SLCPs can slow the rate of warming in the near term. Sustained reductions can also contribute to bringing temperatures down after the peak, alongside deeper CO_2 reductions and carbon dioxide removal.

Methane is particularly important because of the scale of emissions and the effects on climate (see section 6.5.1). So are hydrofluorocarbons, because of their potency as greenhouse gases, and black carbon, since it affects both climate and air quality. Produced mainly by incomplete combustion of fossil fuels and traditional biomass, black carbon is also a component of fine particulate matter ($PM_{2.5}$), which harms health. Because black carbon remains in the atmosphere for only a matter of days or weeks, reducing emissions can quickly slow warming and improve air quality.

International attention to SLCP mitigation has grown. The Global Methane Pledge, launched at COP26, aims to cut anthropogenic methane emissions by at least 30% from 2020 levels by 2030, and it includes 159 countries and the European Union. Meanwhile, the Kigali Amendment to the Montreal Protocol is driving a global phase-down of hydrofluorocarbons (HFCs), which are widely used in refrigeration and air conditioning. Global HFC use is expected to fall by 80-85% by 2047. At COP30, a coalition of countries also launched an initiative to better integrate black carbon mitigation into climate commitments and national planning. As of November 2025, around 17% of Parties had included additional pollutants or emissions sources in their climate commitments.

National action is also increasing, including through support for clean cooking, cleaner vehicles, improved industrial combustion and modern energy access. Countries are developing emissions data, mitigation strategies and targeted policies, such as Canada's Enhanced Methane Regulations, Mexico's National Strategy to Reduce SLCPs and Uganda's National Black Carbon Action Plan. These actions underline the growing momentum behind targeted SLCP mitigation, reflecting recognition of its important role in limiting the magnitude and duration of a temperature overshoot while also delivering immediate air quality and health benefits.

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6.5.3 Temperature implications of IEA scenarios

The long-term global average rise in temperatures above pre-industrial levels was around 1.4 °C in 2025 and has been increasing by around 0.2 °C per decade since 1980 (WMO, 2026). All IEA scenarios exceed warming of 1.5 °C by around 2030, with differences in their temperature trajectories becoming increasingly pronounced after 2035. As highlighted in the *WEO-2025*, pathways that limit warming to 1.5 °C with no or limited overshoot have slipped out of reach, but rapid emissions reductions can still limit the magnitude and duration of the overshoot and avoid much more severe climate outcomes.

In the NZE Scenario, the average temperature increases to over 1.5 °C above pre-industrial levels around 2030 and peaks just below 1.7 °C around 2050. It then gradually declines by 0.04 °C per decade to below 1.5 °C by 2100. The reduction in warming after 2050 reflects natural processes whereby land and oceans absorb atmospheric carbon and reduce its warming effect, a steep drop in emissions of SLCPs such as methane in the preceding decades, and a small additional uptake of CO_2 from afforestation. However, these factors alone would not be sufficient to reduce the temperature rise below 1.5 °C: this outcome is achieved only through the large-scale deployment of CO_2 removal technologies and limited increase in land-use sinks, although in limited amounts compared with IPCC scenarios (Box 6.4).

The temporary overshoot of 1.5 °C nonetheless carries significant risks. In the NZE Scenario, warming exceeds 1.6 °C for almost 40 years and 1.5 °C for around 65 years. Overshooting 1.5 °C intensifies heatwaves, droughts and floods, with particularly severe impacts in low-income regions with limited adaptive capacity, putting additional stress on energy systems and increasing the need for climate-resilient infrastructure (see section 7.6 in Chapter 7). It has serious implications for vulnerable populations, ecosystems and climate tipping elements.

The gap between the NZE Scenario and the other WEO scenarios widens over time. In the CPS, warming exceeds 2 °C around 2050, reaches 2.9 °C by 2100 and continues rising thereafter (Figure 6.24). In the STEPS, warming exceeds 2 °C around 2060 and reaches around 2.5 °C by 2100. The ARC follows a different energy pathway from the STEPS, with higher coal use and lower oil and natural gas consumption, and results in slightly lower warming of around 2.4 °C by 2100. While the difference may appear relatively small, every increment of warming increases climate risks and impacts.

Given uncertainty about the climate's response to future emissions, higher or lower temperature outcomes remain possible. There is about a 17% and 14% chance of warming above 3 °C by 2100 in the STEPS and ARC, respectively, and a 7% chance of exceeding 4 °C in the CPS. Even if the NZE Scenario is achieved in full, there is still about a 12% chance of warming above 2 °C and a 48% chance of not returning below 1.5 °C by 2100. Higher warming also raises the risk of reaching irreversible tipping points and precipitating disasters with profound consequences for societies, ecosystems and the climate system, such as the melting of the Greenland Ice Sheet or the dieback of the Amazon rainforest.

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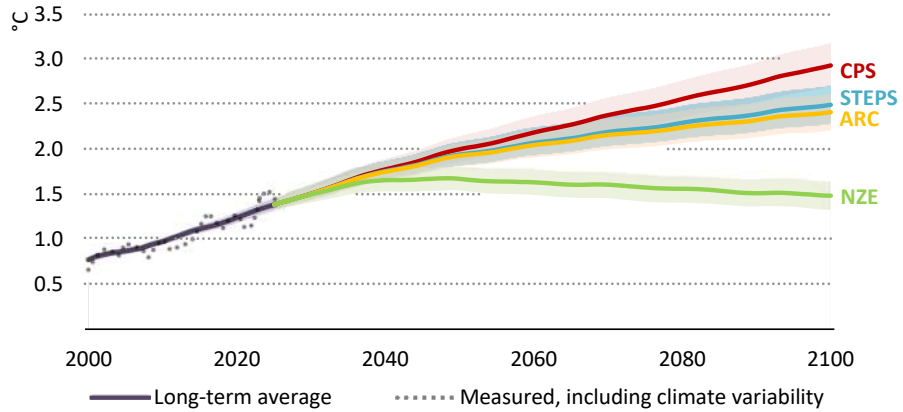
Figure 6.24 ▷ Global average temperature rise by scenario, 2000-2100



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The global temperature continues to rise through to the end of the century in all scenarios apart from the NZE Scenario, where it peaks just below 1.7 °C and falls below 1.5 °C by 2100

Note: Temperature rise relative to 1850–1900. Shaded areas show the 33rd to 67th percentile range; lines show the median (50th percentile).

6.6 Implications of net zero pathways

6.6.1 Fuel security

As the deployment of low-emissions energy accelerates in the NZE Scenario, investment shifts rapidly towards low-emissions energy technologies, electrification and efficiency improvements. Fuel-importing economies see substantial declines in import bills. The share of fuel net imports relative to GDP rapidly declines in advanced economies from about 2% in 2025 to 0.4% by 2035, largely driven by electrification in end-use sectors. The same trend occurs in emerging market and developing economies, with net imports accounting for about 0.8% of GDP by 2035 (Figure 6.25).

However, in the NZE Scenario, fuel supply becomes more concentrated among a smaller number of low-cost producers as overall consumption declines. The share of the Organization of the Petroleum Exporting Countries (OPEC) in global oil production rises to 42% in 2050, while the Middle East's share of crude oil exports increases to more than 70% by 2050. Many countries, especially emerging market and developing economies in Asia, remain highly dependent on imports of oil, notably for energy-intensive industry. The same is true for natural gas, with import dependency in Asia rising to more than 40% in 2050. As a result, importers remain exposed to geopolitical events, physical disruptions in the Middle East and incidents around major trade chokepoints, even though total import volumes decline.

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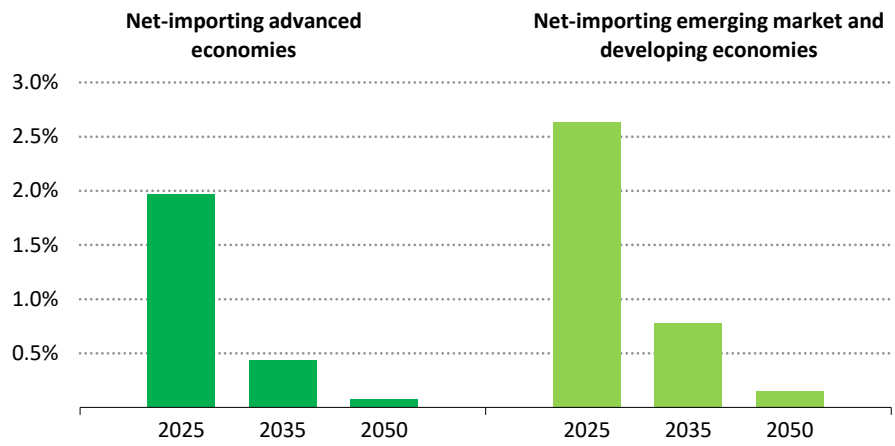
Figure 6.25 ▷ Fuel net-import expenditures as a share of regional GDP in the NZE Scenario, 2025-2050



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Net zero pathways cut fuel import bills, helping to protect importing regions from external price shocks in the long term

For many fuel-exporting economies, lower oil and gas revenues create significant fiscal and macroeconomic challenges: in the NZE Scenario, fuel rents are almost 90% lower in 2050 than they are now. Managing these challenges will require proactive economic diversification, investment in new growth sectors and measures to reduce dependence on hydrocarbon revenues. Reductions in fossil fuel investment and the expansion of low-emissions energy systems will need to be carefully sequenced alongside planning for the maintenance, repurposing and eventual decommissioning of existing infrastructure.

6.6.2 Electricity security

The importance of electricity security increases in the NZE Scenario as electricity rapidly becomes the backbone of energy systems across the world, providing more than half of final energy consumption by 2050. As electrification expands in the transport, buildings and industry sectors, growing shares of variable renewable generation make power systems more complex, and the scale of the potential economic consequences makes the risk of supply disruptions more acute.

Dispatchable capacity is the cornerstone of electricity security today and remains critical in all scenarios. Although variable renewables provide the bulk of electricity generation in most markets for much of the year in 2050 in the NZE Scenario, sufficient dispatchable capacity is needed to bridge periods when low renewable output coincides with high demand. This capacity includes dispatchable renewables such as hydropower, geothermal and bioenergy, as well as low-emissions thermal power sources such as nuclear power plants, fossil fuel

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plants equipped with CCUS, and plants co-firing hydrogen or hydrogen-based fuels. Grids, storage and demand-side flexibility also play essential roles.

Batteries emerge as one of the fastest-growing sources of system flexibility. Driven by falling costs and the increasing need to absorb surplus renewable generation and meet peak demand, global battery capacity expands more than eleven-fold in the NZE Scenario to over 3 300 GW by 2035. While batteries are well suited to providing short-duration flexibility, longer-duration storage technologies such as pumped storage hydropower also play an important role in ensuring system adequacy.

Demand-side flexibility becomes an increasingly valuable resource in all scenarios, including the NZE Scenario. Smart controls, digital technologies, artificial intelligence applications and market incentives enable consumers, electric vehicles, heat pumps and industrial processes to adjust consumption in response to system needs, reducing overall balancing requirements and improving system resilience.

Electricity grids similarly remain a central pillar of energy security. Large-scale investment in transmission and distribution networks is required to connect new sources of generation, accommodate rising electricity demand and strengthen system resilience. Together with flexibility resources, grid expansion and modernisation are essential to ensure that increasingly electrified and renewable-based energy systems remain reliable, affordable and secure.

6.6.3 Critical mineral security

As the accelerating deployment of low-emissions technologies drives a rapid increase in material requirements, critical mineral supply security becomes an even greater challenge in the NZE Scenario than it is already. Demand for copper – a foundational material for electricity networks, renewable power and electrification – is around 20% higher in 2035 in the NZE Scenario than in the STEPS. Demand for lithium is around 70% higher, and requirements for nickel, cobalt and graphite are between 25% and 50% higher.

While concerns about the geographical concentration of production and processing remain central, the nature of the challenge evolves, and securing sufficient volumes of critical minerals becomes as important as diversifying their sources. Recent investments and project announcements have improved supply prospects for several minerals, reducing some of the supply risks identified in previous years, but these developments are insufficient to meet the needs of a net zero pathway. In the NZE Scenario, expected supply from existing and announced projects falls short of projected demand for most key minerals by 2035, even assuming continued improvements in technology performance and material efficiency. Copper emerges as the most significant challenge: projected primary supply in 2035 covers less than two-thirds of expected demand, implying a supply gap of more than 30%.

These gaps highlight that the transition to net zero is a materials challenge as well as an energy challenge. Disruptions to shipping through the Strait of Hormuz in 2026 have also been a reminder of the vulnerability of other material supply chains, including those for

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metals and gases like aluminium, sulphur and helium. Meeting these challenges will require a combination of accelerated project development, investment across the mining and processing value chains, stronger recycling systems and continued technological innovation to reduce material intensity. Delays in any of these areas would increase pressure on supply chains and heighten the risk of market tightness.

Critical minerals underpin many of the technologies central to energy transitions, including electricity networks, batteries, solar PV, wind turbines and electric vehicles (Box 6.6). Persistent supply constraints or periods of price volatility could increase technology costs, slow deployment rates and raise the overall cost of achieving climate objectives. They could also undermine efforts to diversify low-emissions energy manufacturing, reinforcing existing supply chain dependencies and limiting opportunities for industrial development in emerging market and developing economies.

Box 6.6 ▻ Aligning low-emissions technology manufacturing with net zero needs

The market for low-emissions energy technologies has grown by around 20% per year on average since 2015 and was worth nearly USD 1.2 trillion in 2025. Manufacturing capacity is highly geographically concentrated: China accounted for around 85% of global solar PV supply capacity and 80% of global battery capacity in 2024, while upstream steps like wafer and anode production are even more heavily concentrated (IEA, 2026h).

Low-emissions technology deployment rises in all IEA scenarios, but it expands most strongly in the NZE Scenario, in which the aggregate global market value of key low-emissions energy technologies exceeds USD 5 trillion by 2035. Electric cars remain by far the largest segment of this market, but demand for batteries, solar PV and other low-emissions technologies also grows quickly. The rapid uptake of these technologies is broad-based in the NZE Scenario, with demand in emerging market and developing economies growing by 15% per year on average through 2035. This growth has the potential to support industrial development, employment and energy security, but it depends on investment in critical minerals, processing, component production, recycling, infrastructure and workforce development as well as final manufacturing.

Existing manufacturing capacity for solar PV modules is already sufficient to meet demand levels in the NZE Scenario by 2030, provided it is fully utilised (Figure 6.26). However, as the transport sector electrifies in the NZE Scenario, demand for electric vehicles and battery cells accelerates beyond the maximum capacity of existing manufacturing facilities. There is sufficient additional manufacturing capacity in the project pipeline to satisfy demand in 2030 for both technologies; that said, this projected surplus capacity should be interpreted with caution, given a degree of uncertainty around the utilisation rates that can be achieved for new manufacturing installations. In addition, there are potential bottlenecks associated with EV and battery supply chains, notably those for some critical minerals. The future trade and industrial policy landscape is another key area of uncertainty.

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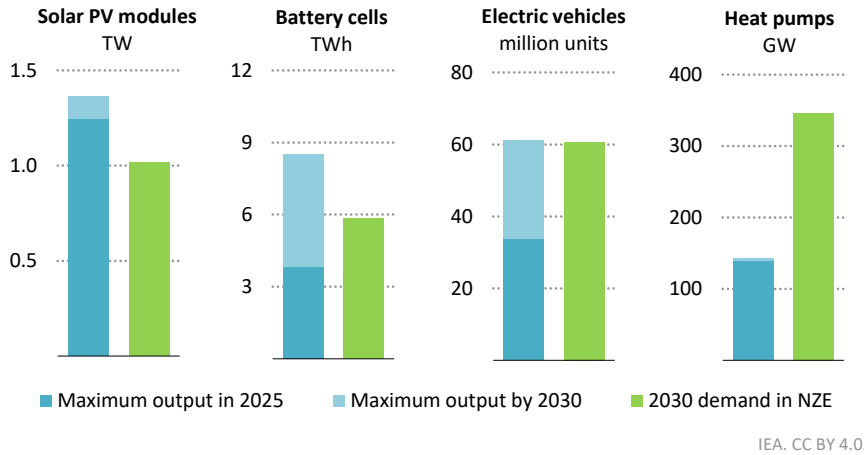
For other technologies, the risk of a manufacturing capacity shortage in the coming years looms larger still. For example, only around half of the demand for heat pumps in the NZE Scenario in 2030 could be met with the projected output from existing and announced capacity.

Figure 6.26 ▷ Existing and announced manufacturing capacity for selected low-emissions energy technology supply chains, 2030



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Today's maximum manufacturing output falls short of 2030 deployment needs in the NZE Scenario, but announced additions could close the gap in most cases

Note: TW = terawatts.

6.6.4 Energy investments

Unlocking greater levels of investment is a prerequisite for the NZE Scenario. The transformation of the energy sector in the NZE Scenario implies a large-scale deployment of technologies with high upfront capital costs but low operating costs, as well as electrification and efficiency improvements. As a result, average annual low-emissions energy investment triples to around USD 4.5 trillion in the decade to 2035 compared with the previous decade (Figure 6.27).

The power sector attracts more capital than any supply and end-use sector, with global investment rising to USD 2.8 trillion per year by 2035 in the NZE Scenario, driven by the rapid expansion of renewable generation, grids, storage and nuclear capacity. Annual average spending on renewable power reaches USD 1.4 trillion to 2035, a tripling from the previous decade, reflecting its importance in meeting new electricity demand and displacing fossil fuel generation.

Average annual investment in nuclear power triples compared to the previous decade, with spending averaging USD 275 billion per year. Annual average investment rises to around

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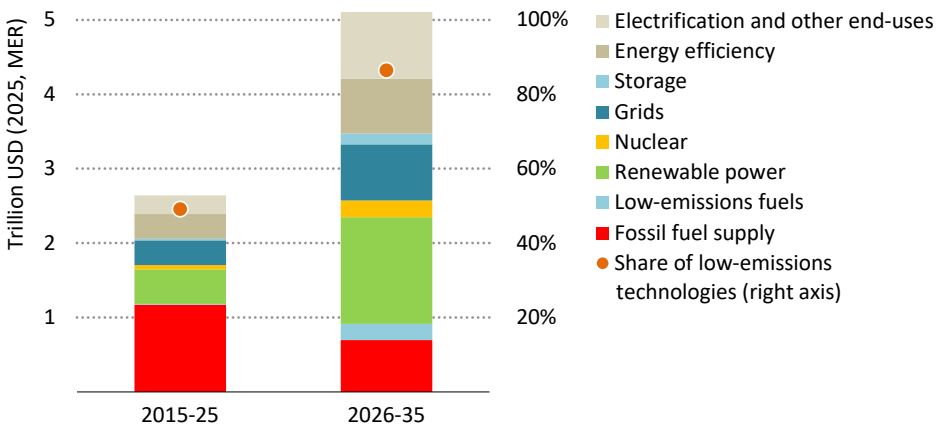
USD 525 and 150 billion for grids and storage respectively, with annual investments for storage seven times higher on average than in the previous decade, outpacing the acceleration for transmission and distribution lines. In 2035, around 50% of the investments made in fossil fuel-based electricity generation in the NZE Scenario are in CCUS, up from less than 3% in 2025.

Figure 6.27 ▷ Average energy investment in the NZE Scenario, 2015-2035



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Average annual low-emissions energy investments triple in the NZE Scenario by 2035 compared with the last ten years, notably for power generation

Note: MER = market exchange rate.

The electrification of transport, buildings and industry also involves major investment. The large-scale deployment of electric vehicles, heat pumps and electric industrial equipment pushes annual average investment in electrification to USD 800 billion by 2035, almost three times the levels seen in the last five years. At the same time, spending on energy efficiency rises sharply across all end-use sectors, reducing energy demand growth and lowering the supply-side investment required over the long term. Average annual investment in energy efficiency in the buildings sector approaches USD 535 billion over the next decade. Investment in transport and industry efficiency also rises substantially, nearly doubling from the average levels of the last five years to around USD 135 billion and nearly USD 70 billion per year, respectively.

The transition also reshapes investment in fossil fuel supply. Annual investment in unabated fossil fuels declines as demand falls, but it does not disappear. Continued investment is undertaken to offset natural decline rates in existing oil and gas fields, maintain critical infrastructure and ensure secure energy services throughout the transition. Conversely, investment in fossil fuels with CCUS rises rapidly over time, reaching USD 130 billion in 2035.

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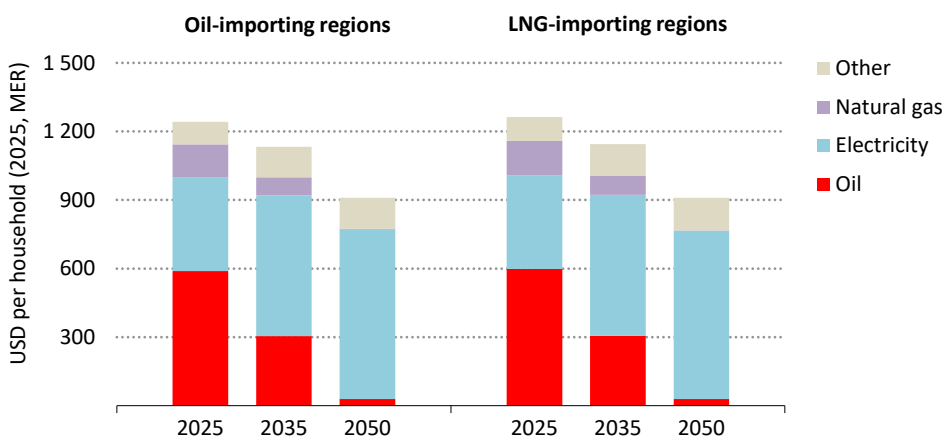
6.6.5 Energy affordability

How changes in investment, fuel prices and operating costs ultimately affect energy affordability for end-users is a central consideration in all scenarios. In the NZE Scenario, the transition changes household expenditures through three main channels: higher upfront spending on low-emissions energy equipment and efficiency improvements; a shift in recurring expenditures on fossil fuels towards electricity; and policy interventions, including carbon pricing, fossil fuel subsidy reform and financial support for low-emissions technologies. The analysis here considers household residential and road transport energy use, complementing the chapter's wider assessment of investment needs and the implications of net zero pathways.

The rapid shift towards electrification and low-emissions energy development progressively reduces household exposure to fuel prices and lowers average energy bills from current levels by around 5% by 2035 globally. As electric vehicles replace internal combustion engine cars and electric heating displaces natural gas and oil, average household spending on oil products almost halves from USD 660 per year in 2025 to around USD 380 in 2035, and spending on natural gas declines from about USD 140 to USD 105. Meanwhile, electricity expenditure rises from around USD 440 to USD 635, but this increase is outweighed by the decrease in spending on oil products and natural gas. This trend is more pronounced in countries that import oil and liquefied natural gas (LNG): in the NZE Scenario, overall household energy bills in these countries decline from current levels by almost 10% by 2035 and more than 30% by 2050 (Figure 6.28).

Figure 6.28 ▷ Household energy bills in oil- and LNG-importing regions in the NZE Scenario, 2025-2050



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In the NZE Scenario, household energy bills in oil- and LNG-importing regions are almost 10% below their 2025 level in 2035 and more than 30% lower by 2050

Notes: LNG = liquefied natural gas. Other includes energy spending for district heating, bioenergy and hydrogen.

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The reduction in bills in the NZE Scenario reflects changes in the fuels used and lower energy consumption for a given level of service. Electric vehicles convert energy into mobility more efficiently than internal combustion engine vehicles, while heat pumps provide several units of heat for each unit of electricity consumed. Building renovations and more efficient appliances further reduce household energy needs. As a result, additional household investment in low-emissions energy technologies is progressively offset by savings on fuels, maintenance and other operating costs.

The effects are not uniform across households. Lower-income households tend to spend a larger share of their disposable income on energy and therefore stand to benefit significantly from lower recurring bills. However, they are also less able to finance the upfront cost of an electric vehicle, heat pump or building retrofit, and they may face higher borrowing costs or lack access to credit. Without targeted support, the households that would benefit most from operating cost savings could be among the least able to make the necessary investments.

Policy design plays a central role in determining how the costs and benefits of the transition are distributed. In the NZE Scenario, carbon pricing and the reform of untargeted fossil fuel subsidies raise the price of some fossil fuel uses, while incentives reduce the cost of low-emissions equipment. Removing fossil fuel subsidies can create fiscal space, and carbon pricing can generate additional public revenue, but reforms need to be carefully sequenced and factor in the risk that near-term energy costs for vulnerable households may rise. Recycling revenues through targeted transfers, social tariffs, concessional finance or support for low-emissions energy equipment could protect such households while enabling them to participate in the transition.

6.6.6 Energy employment

The NZE Scenario sees 15.6 million net job additions in the energy sector by 2035 (Figure 6.29). Around three-quarters of these additions are associated with the construction of new low-emissions power capacity and grid infrastructure. Electrification of end-uses is another area of growth, with EVs and their batteries accounting for over 90% of vehicle manufacturing employment in 2035, while the number of jobs associated with heat pumps in 2035 is more than twice as high as in 2025. These gains are accompanied by a 50% drop in jobs in the fossil fuel supply sector by 2035. Managing this shift would require policies that support workers and local communities through the transition.

In the NZE Scenario, the rate of workforce expansion increases from 1.1% per year between 2015 and 2025 to 1.8% in the coming decade. Such a rapid increase in labour demand would inevitably place significant strain on the supply of skilled workers, intensifying shortages that are already evident in many key energy occupations. An ageing energy workforce adds to the challenge, particularly in advanced economies and in critical sub-sectors such as grids.

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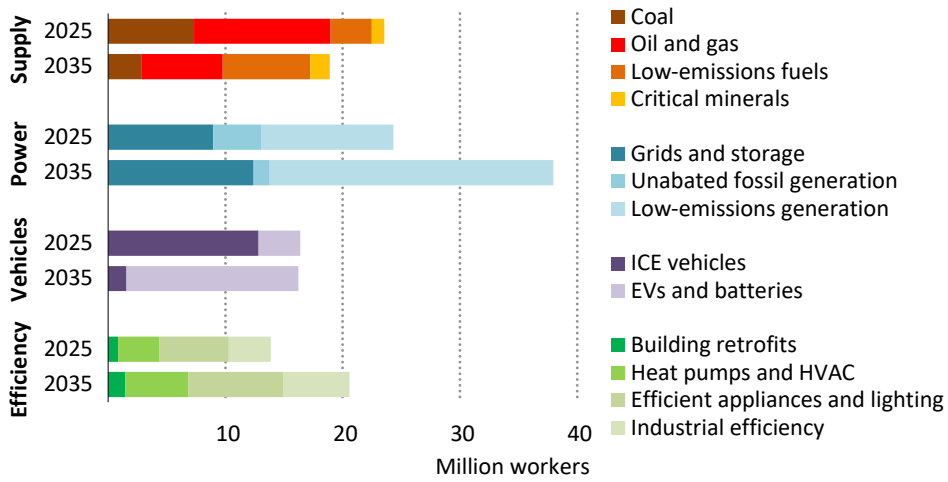
Figure 6.29 ▷ Energy employment by sector in the NZE Scenario, 2025 and 2035



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The NZE Scenario creates over 15 million net new jobs globally by 2035, of which three-quarters are needed to develop new low-emissions power infrastructure

Note: ICE = internal combustion engine; HVAC = heating, ventilation and air conditioning.

Expanding vocational education and training capacity will be essential to prevent labour shortages from constraining deployment. It is also crucial that curricula evolve in step with technological change to ensure those being trained acquire the skills required in emerging industries such as battery manufacturing. Addressing the gender imbalance in the energy workforce would also help ease labour supply pressures: at present, women account for only one in five workers in the energy sector.

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PART D
IMPLICATIONS AND REGIONAL INSIGHTS

Part D of the World Energy Outlook 2026 explores the implications of different energy pathways for energy security and affordability and looks at how priorities and choices vary across countries and regions.

Chapter 7 examines the implications of the IEA's scenarios for energy security and affordability. It considers the evolving challenges that countries face as they seek to ensure the security of the fuel, electricity and critical mineral supplies they depend on, while at the same time strengthening resilience and making faster progress on delivering energy access for all. This involves an assessment of what different policy choices mean for exposure to, and protection from, energy security vulnerabilities. It concludes with a look at how and why energy bills for households and businesses could change over time.

Chapter 8 presents regional insights across major regions accounting for 90% of global energy demand. It explores how differing resources, economic circumstances and policy priorities shape energy pathways.



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Implications for energy security and affordability

Straitened circumstances

SUMMARY

- Recent crises underline the need for secure, affordable energy. This presents policy makers with a multifaceted challenge, and possible ways forward reveal synergies but also difficult trade-offs, making comprehensive approaches critical.
- Improving fuel security requires diversity of suppliers and routes, adequate storage and spare capacity, and investment in legacy assets and new infrastructure, with needs varying markedly by scenario. Fuel-importing regions cut oil and gas imports by around 15% to 2035 in the Additional Response Case (ARC), mainly through efficiency and electrification, while imports remain broadly flat in the Stated Policies Scenario (STEPS).
- In terms of **electricity security**, electrification can reduce exposure to traded fuels but brings new risks. Peak demand for electricity grows by 40-50% by 2035 across scenarios, while shares of solar photovoltaics and wind rise rapidly. System adequacy therefore requires new capacity and robust grids, while flexibility requires more storage, demand response and diverse generation mixes.
- **Critical minerals** have moved to the forefront of energy and national security. Both mining and refining are heavily concentrated, with the top supplying country holding 85% of refined magnet rare earth and around 75% of refined lithium and cobalt supply. There are also some gaps between existing and planned supply and projected demand, including a 25% deficit for copper by 2035 in the STEPS.
- Building greater systemic **resilience** is essential, with energy infrastructure increasingly at risk from severe weather and malicious attacks. Each year, an average of 190 million customers are reported to experience power outages linked to natural hazards, and exposure is set to worsen as temperatures rise. Proven measures can mitigate these risks but often require additional investment.
- The lack of **energy access** is the most fundamental form of energy insecurity. Around 720 million people still lack access to electricity, and 2 billion lack access to clean cooking technologies. Universal access requires more investment to expand grids, mini-grids and renewables, and to fund the equipment and infrastructure necessary to make liquefied petroleum gas and other clean cooking options widely available.
- Concerns about **affordability** have intensified after recent fossil fuel price spikes. For importers, energy system costs are lower in scenarios that see faster energy transitions, but this requires large upfront investments in more efficient technologies.
- Policy decisions will have impacts on emissions. In several net-importing countries, the most effective way to improve energy security is to boost investment in clean energy technologies, which accelerates emissions reductions; in others, coal-fired generation capacity remains a key part of electricity security.

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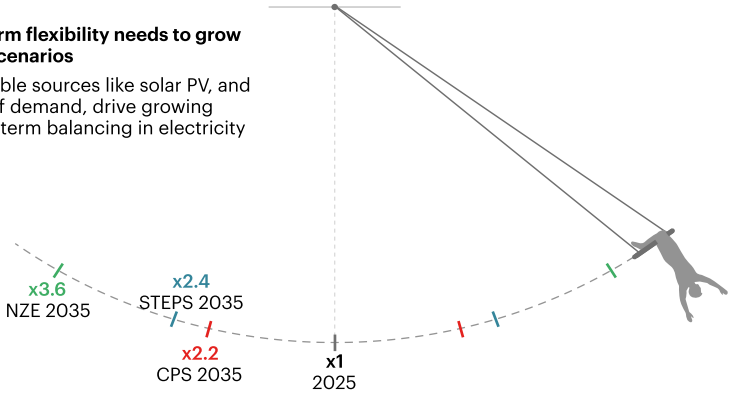
The pillars of energy security

Energy systems can draw on a range of attributes or principles to protect against vulnerabilities and hazards.



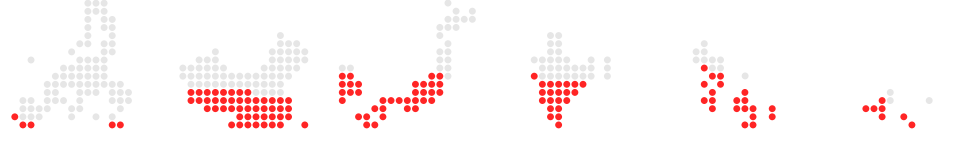
Global short-term flexibility needs to grow strongly in all scenarios

The rise of variable sources like solar PV, and electrification of demand, drive growing needs for short-term balancing in electricity systems.



Imports through the Strait of Hormuz, 2025

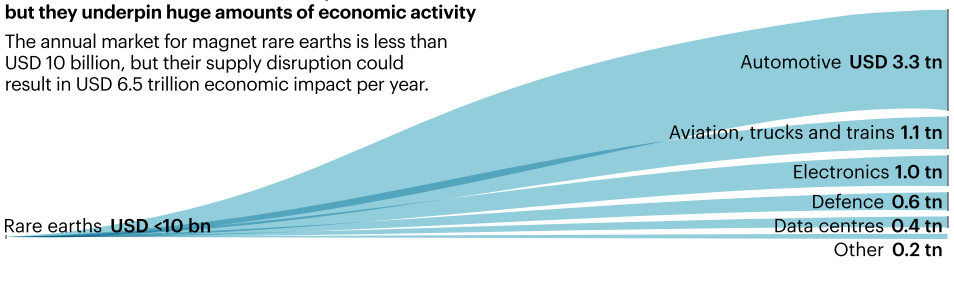
Each dot ● represents 0.1 mb/d of crude oil imports. Red dots ● pass through Hormuz. The percentages indicate the share of imports via Hormuz.



European Union	China	Japan and Korea	India	Southeast Asia	Other Asia
Crude oil 6%	Crude oil 44%	Crude oil 63%	Crude oil 41%	Crude oil 66%	Crude oil 65%
LNG 8%	LNG 31%	LNG 11%	LNG 60%	LNG 21%	LNG 60%

Critical mineral markets are relatively small, but they underpin huge amounts of economic activity

The annual market for magnet rare earths is less than USD 10 billion, but their supply disruption could result in USD 6.5 trillion economic impact per year.



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7.1 Introduction

Energy security is defined by the IEA as the uninterrupted availability of energy sources at affordable prices. The 2026 energy crisis, coming so soon after the global energy crisis sparked by Russia's full-scale invasion of Ukraine in 2022, is leading many governments to recalibrate their policy priorities to focus on how to protect households and industries against the risks of supply disruptions and unaffordable energy.

In setting energy and economic policy frameworks, governments must grapple with both traditional and new energy security opportunities, hazards and risks. They also have to look at issues in a comprehensive manner, weigh trade-offs and make difficult judgements. While some options to improve one aspect of energy security could strengthen others and help achieve additional policy objectives, different choices could weaken other aspects of energy security or involve trade-offs with other policy goals.

There is no single pathway to follow. The 2022 and 2026 energy crises have constrained national budgets, and increasingly frequent instances of extreme weather present a challenging and uncertain backdrop for decision-making. Countries and regions start from very different positions: some have abundant domestic energy resources, while others have few; some use energy much more efficiently than others; some have invested more heavily in protection against energy security risks; and some have highly developed existing energy infrastructure, while others lack full access to energy, the most fundamental form of energy insecurity.

This chapter explores what different policy choices mean for exposure to, and protection from, energy security vulnerabilities, as well as the broader implications of these choices. This includes examining those implications through the lenses of our main scenarios: the Current Policies Scenario (CPS), the Stated Policies Scenario (STEPS) and the Net Zero Emissions by 2050 (NZE) Scenario. It also incorporates the Additional Response Case (ARC), which looks at new measures that countries might introduce to reduce their exposure to future shocks in response to the impacts of the recent crises; the Low Hormuz Case (LHC), which looks at the options open to countries to reduce exposure to transit through the Strait of Hormuz; and the Accelerating Clean Cooking and Electricity Services Scenario (ACCESS), which charts a pathway to achieve universal access to clean cooking and electricity.

This chapter is structured around the properties that can make an energy system more secure (Box 7.1), and it identifies these by looking at the key vulnerabilities that policy makers must consider when deciding where action is needed. It starts by examining system-wide risks before looking in detail at the security of fuels, electricity and critical minerals, and at the implications of energy security concerns for resilience, energy access and affordability. It concludes by exploring some of the synergies and trade-offs between different dimensions of energy security, as well as between energy security and other policy goals.

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Box 7.1 ▻ Conceptualising energy security

Energy security vulnerabilities extend across many parts of the system and include exposure to volatile fossil fuel prices, high import dependence, dominant suppliers, highly concentrated supply chains or trade routes, insufficient stocks or storage, limited electricity system flexibility and weak cyber defences.

Hazards are potential disruptive events, such as the closure of a chokepoint. Risk is a measure of the likelihood of a hazard interacting with a vulnerability and the probable consequences of it doing so. For example, restrictions on trade through the Strait of Hormuz are an energy security hazard the world has been aware of for some time, while the high level of dependence of many countries on oil and liquefied natural gas (LNG) shipments through this chokepoint is a strategic vulnerability. Taken together, this exposes the global energy system to the risk of price spikes and economic disruption.

Energy systems can draw on a range of attributes or principles to protect against vulnerabilities and hazards. We focus on five key properties of secure energy systems. These properties can overlap, but they span differing timeframes, and their relevance varies across fuels, electricity and critical minerals:

- **Adequacy:** the ability of a system to meet demand at all times under normal operating and stress conditions
- **Flexibility:** the ability of a system to handle variations in, and maintain a continuous balance between, supply and demand over both short- and longer-term periods
- **Resilience:** the ability to absorb the effects of a short-term disruption external to the energy system, such as extreme weather, cyberattacks and other malicious attacks, and recover a certain performance level
- **Diversity:** the maintenance of a range of energy sources, suppliers, routes, technologies and fuels to meet energy demand and supply intermediate conversion processes
- **Robustness:** the maintenance of long-term capability and system stability across a wide range of operating and stress conditions.

Market transparency, international co-operation and strong institutions underpin all five of these properties by enabling co-ordinated planning and timely investment. Reliable data, shared expertise and established emergency protocols can help governments and industry identify vulnerabilities early and respond collectively to disruptions.

In our scenario modelling, there is an important difference between risks that all scenarios are designed to reduce to acceptable levels under expected operating conditions (e.g. ensuring there is sufficient flexibility and adequacy in electricity systems so that spikes in electricity demand do not lead to blackouts) and risks that vary according to the policy choices and system configurations reflected in the scenarios (e.g. the extent

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of reliance on flows of oil and gas through chokepoints, and the likelihood of extreme weather events). This distinction matters: while some energy security risks may appear less likely or consequential than others in the scenario results, this is often because policy choices and investment have already helped avoid or mitigate them.

7.2 System-wide security

Although energy security hazards and risks often play out at the level of individual fuels, sectors or technologies, some are cross-cutting or systemic. For example, the interruption of a flow of fuels through a key maritime chokepoint may result in physical disruptions, which can then have knock-on implications for all parts of the energy system, including electricity supply, and the broader economy. These risks are heightened by excessive reliance on the disrupted fuels. This section examines how key system-wide indicators evolve across IEA scenarios.

7.2.1 Diversity

The first way to reduce exposure to disruptions affecting individual fuels and technologies is to diversify energy sources. Renewables have a key role to play in reducing the dominance of fossil fuels, and their share of the energy mix is growing rapidly in many regions. Although energy mixes are relatively slow to change, the share of fossil fuels in the primary energy mix falls from 79% today to 73% in the CPS and 71% in the STEPS in 2035 (Figure 7.1). Renewables are also overwhelmingly produced locally, and their rate of growth rises in the ARC, which favours domestic energy resources. In the ARC, the share of fossil fuels drops to less than 70% in 2035, and the share of domestic sources in total energy supply rises from 76% today to 79% by 2035, while it remains flat in the CPS and in the STEPS. The rise of renewables is much faster in the NZE Scenario, in which a doubling in clean energy investment compared with the STEPS leads the share of fossil fuels globally to drop to around 50% in 2035. A more diversified energy mix helps to spread supply risks and reduce exposure to price shocks during a crisis. At the margin, it can also create options to switch fuels or technologies if one source becomes scarce.

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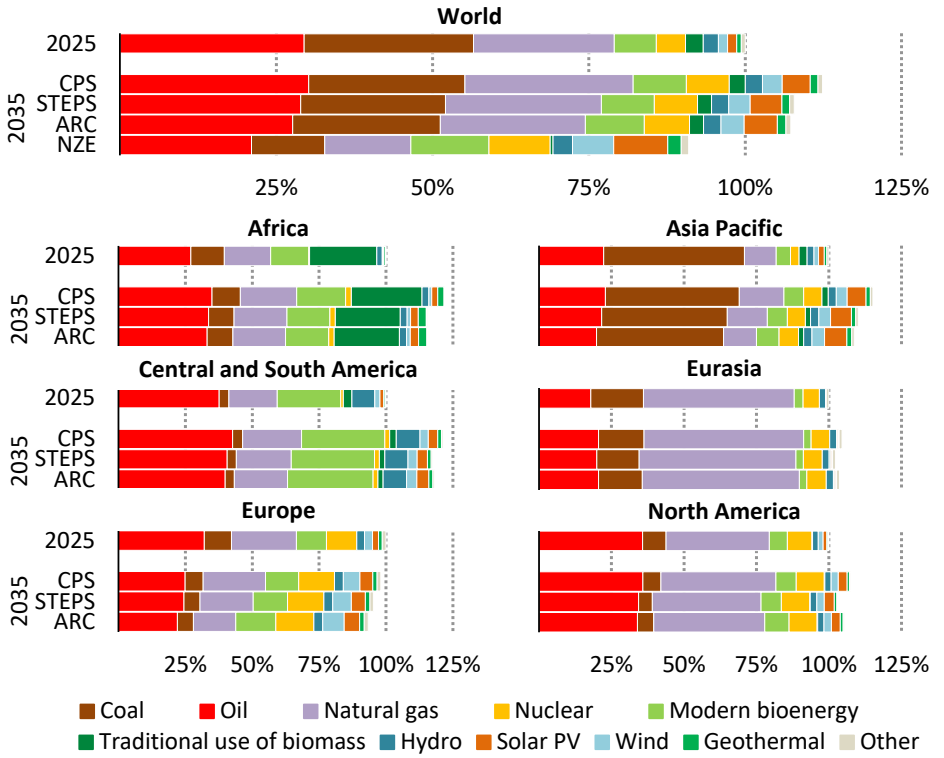
Figure 7.1 ▷ **Share of primary energy sources in total demand relative to 2025 levels by region and scenario, 2025 and 2035**



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Renewables dominate energy additions to 2035, helping to diversify the global energy mix; diversification proceeds fastest in the NZE Scenario

Notes: STEPS = Stated Policies Scenario; CPS = Current Policies Scenario; NZE = Net Zero Emissions by 2050 Scenario; ARC = Additional Response Case; PV = photovoltaics. Other includes waste and marine energy. Total energy demand in 2025 is indexed to 100%.

Fossil fuel imports and dependence

Well-functioning international energy markets allow importers to benefit from resources that would be much more costly or impossible to produce domestically, and exporters to generate export revenue and employment. Such markets therefore deliver energy security benefits by providing access to a larger, more flexible pool of energy resources that can be allocated efficiently to align with demand. However, heavy reliance on imports can also heighten exposure to geopolitical shocks, infrastructure failures and swings in global markets, while a high degree of concentration among suppliers and trade routes can create structural vulnerabilities that amplify the risks associated with disruption to a single supplier, corridor or chokepoint.

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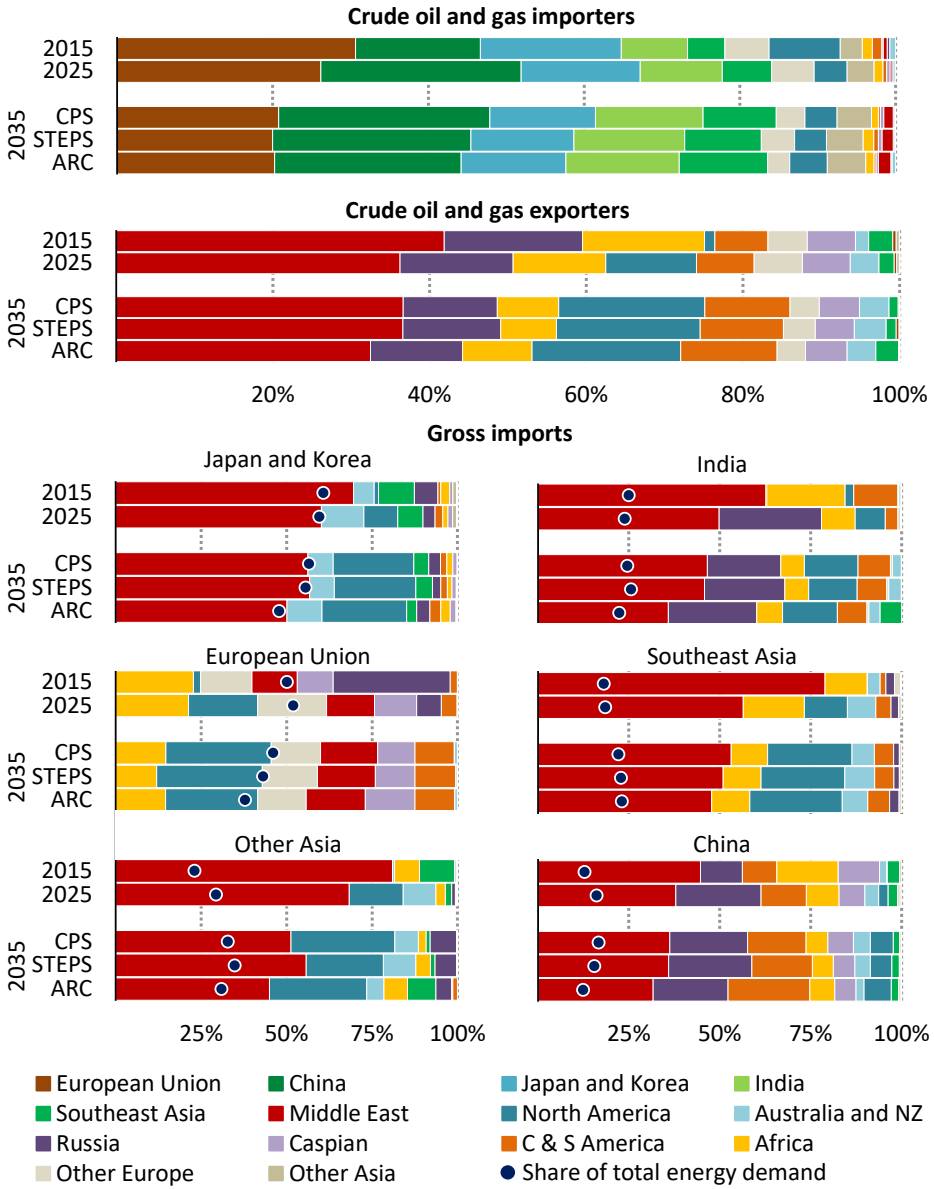
Figure 7.2 ▷ **Crude oil and natural gas imports and exports in selected regions by scenario, 2015, 2025 and 2035**



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In the ARC, lower import levels reduce reliance on established exporters like the Middle East and allow for greater diversification from growing suppliers in the Americas

Notes: NZ = New Zealand; C & S America = Central and South America. Total energy demand includes international bunkers.

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The degree of reliance on oil and gas imports varies markedly between regions today,[1] with imports accounting for more than 60% of the energy used in Japan and Korea, and around 50% in the European Union, 25% in India and 15% in China (Figure 7.2). Both the CPS and STEPS see imports by the European Union decline by around ten percentage points to 2035 relative to overall energy demand, reflecting efficiency gains and a growing share of renewables. However, lower overall energy demand in the STEPS means that this decline in import dependence translates into a reduction in absolute import volumes that is 25% larger than in the CPS. In contrast, led by Indonesia, many countries in Asia see strong increases in import requirements to 2035 as rising demand outpaces domestic sources of supply. In the ARC, the additional demand-side measures deployed by importers around the world and efforts to boost domestic production result in lower import dependence across the board. In the NZE Scenario, imports fall to very low levels.

Countries and regions also vary widely in their reliance on specific exporters. In recent years, the European Union has shifted away from imports from Russia and significantly increased the share of energy it imports from the United States, which was its largest single source of oil and gas imports in 2025. Exports from North America to Japan and Korea have also increased, and North America now ranks as their third-largest source of imported energy. Increased imports from Australia and North America have helped Japan and Korea to cut reliance on oil and gas imports from the Middle East from 70% a decade ago to around 60% today. In the CPS and STEPS, the Middle East remains the dominant source of imports for most countries in Asia, while the European Union continues to import energy from a relatively broad range of regions. In the ARC, importers improve security primarily through lower import volumes, but there is a marginal increase in supplier diversity compared with the STEPS. The reduction in imports by advanced economies means China and India become an increasingly important part of exporters' portfolios. In the NZE Scenario, much lower import needs and markets with ample supply provide greater scope to diversify suppliers.

Although diversification has many merits, importers need to weigh them against the benefits of trade with a smaller number of trusted suppliers. Importers similarly need to assess the different advantages of securing volumes through long-term contracts at agreed prices (which bring certainty but can reduce volume flexibility and may increase exposure to unplanned outages or infrastructure disruptions) and maintaining exposure to spot markets (which are more flexible and diverse but also more volatile).

7.2.2 Robustness

Energy intensity

During the energy crises of the 1970s, the world used around three times more oil to produce a unit of gross domestic product (GDP) than today. This reduction in the oil intensity of GDP

[1] Net annual cross-border electricity trade currently amounts to around 3% of global power generation, although over short timeframes, these flows often play an important role in balancing variations in supply and demand.

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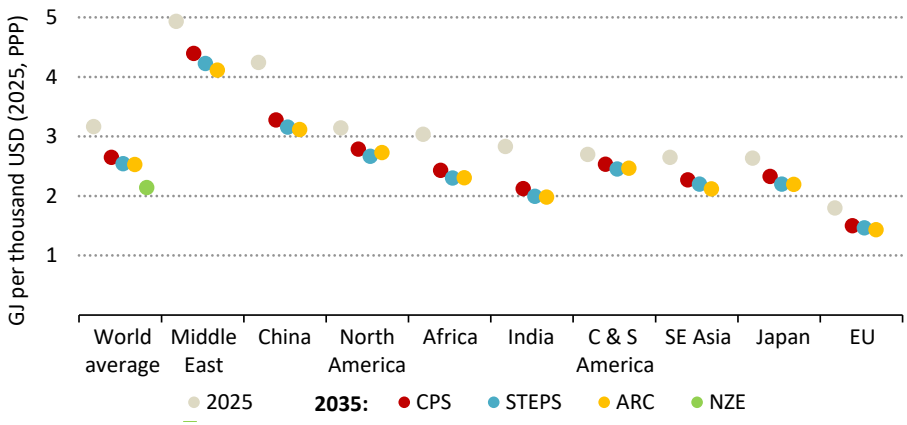
is an important reason, but not the only one, why recent energy crises have not been more disruptive for economic activity. Reducing the energy intensity of economic activity is central to improving the robustness of energy systems for all sectors and fuels within a country. Different technologies can deliver the same level of energy services with varying levels of energy consumption, and energy efficiency gains reduce energy consumption while maintaining economic growth and development goals. Lowering energy intensity also makes it easier to diversify the energy mix, as new sources of supply can more quickly cover a meaningful share of demand.

Figure 7.3 ▷ Energy intensity of GDP in selected countries and regions by scenario, 2025 and 2035



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The lower energy intensity of GDP in all scenarios to 2035 reduces exposure to supply disruptions and price shocks, with China and India showing some of the largest declines

Note: GJ = gigajoule; PPP = purchasing power parity; SE Asia = Southeast Asia; EU = European Union.

In the CPS, the global average energy intensity of GDP falls by slightly more than 15% between 2025 and 2035, and by around 20% in the STEPS (Figure 7.3). Fast-growing emerging market and developing economies, including Africa and India, see large falls in energy intensity from 2025 levels. The European Union, Japan and Korea start from relatively low levels of energy intensity, so their scope for further reductions is more limited, although continued gains remain important for limiting exposure to external supply risks. Meanwhile, China and the Middle East remain among the most energy-intensive regions. In the ARC, importers see a somewhat larger decline in energy intensity than in the STEPS, but this is offset by higher intensity in some exporting regions. In the NZE Scenario, rapid efficiency improvements reduce the energy intensity of the global economy by one-third by 2035.

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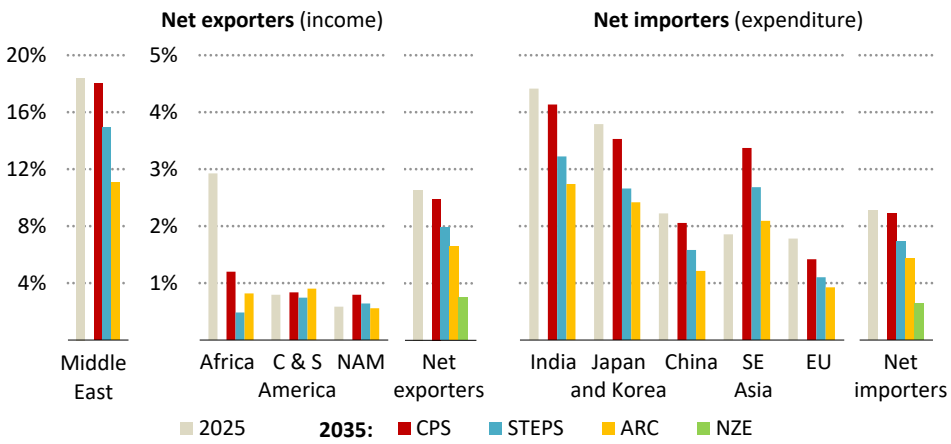
Exposure to price shocks

The ratio of fossil fuel trade balances to GDP indicates the macroeconomic exposure of a country to international fuel price shocks. Today, the main importing regions spend around 2-4% of GDP on fossil fuel purchases (Figure 7.4). In the CPS, Southeast Asia sees the biggest increase in this ratio, with expenditure on fossil fuel imports rising from 2% today to more than 3% of GDP in 2035; in the ARC, however, its spending on imports as a share of GDP remains close to today's levels. The same trend holds in China and the European Union, where imports as a share of GDP in 2035 in the ARC are more than one-third lower than in the CPS as a result of efforts to reduce demand for imported fuels. In India, imports as a share of GDP remain at around their current level in the CPS through to 2035, fall substantially in the STEPS and are lower still in the ARC. Exposure to price shocks depends not just on the ratio of fossil fuel trade balances to GDP but also on market structure: for example, in regions where natural gas regularly sets the marginal electricity price, a gas price spike can lead to wider changes in consumer prices.

Figure 7.4 ▷ Net trade income and expenditure on fossil fuel trade as a share of GDP by region and scenario, 2025 and 2035



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By 2035, expenditure on fossil fuel imports is over 4% and 3% of GDP in India and Southeast Asia respectively in the CPS; the STEPS sees lower import bills as a share of GDP

Note: NAM = North America.

For fossil fuel exporters, income from exports as a share of GDP indicates the degree of economic dependence on this revenue stream. The share was highest in the Middle East, with fuel exports representing almost 20% of GDP in 2025; this became a major vulnerability in 2026 with the loss of Gulf export volumes and revenues during the crisis. In the CPS, this share remains steady to 2035, and in the STEPS, it falls to 15%. Other exporting regions have more diversified economies. In North America, fossil fuel export income remains below 1%

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of GDP in 2035 in all scenarios. In Central and South America, supply growth from producers including Brazil and Guyana results in a large increase in exports, but export income plateaus as a share of GDP as a result of fast overall economic development. In Africa, strong domestic demand and economic development, coupled with stable production, reduce export income as a share of GDP by a factor of two to six across scenarios.

7.3 Fuel security

Oil and natural gas sit at the intersection of geopolitical risk, affordability pressures and trade. Recent crises have shown how quickly dependencies can become vulnerabilities, especially where import needs are high, suppliers are concentrated, infrastructure is exposed or trade routes are disrupted. Market balances may ease in some cases – for example, through the upcoming wave of new LNG supply – but will not remove the need for vigilance from both importers and exporters. This section examines how oil and gas vulnerabilities differ across regions and evolve over time, and how the policy decisions made by countries change exposure to these vulnerabilities.

Coal is covered more selectively in this section because its trade profile and security risks differ from those of oil and natural gas. A smaller share of coal (around 20%) crossed international borders in 2025 than natural gas (30%) or crude oil (nearly 50%); it is more easily stored than oil and gas; and coal resources are more widely distributed and available in many regions. This means that coal generally carries fewer acute risks than oil and gas in terms of import dependence, supplier concentration and chokepoints.

7.3.1 Robustness

Natural declines in oil and gas supply

A key and often overlooked vulnerability for oil and gas supplies is the decline in output that occurs naturally over time from existing sources of production. In the absence of any upstream investment, oil and gas supply would fall by around 8-9% per year, a rate of decline far faster than the changes in demand in any scenario (including the NZE Scenario). Even with investment continuing at existing fields, supply would still fall by around 4-5% per year (Figure 7.5). Consequently, almost 90% of the nearly USD 550 billion invested in upstream oil and gas each year over the past five years has simply offset production declines rather than gone towards meeting demand growth (IEA, 2025a).

Natural decline rates have become steeper over time, because of higher reliance today on unconventional sources, changes in the mix of conventional production (such as more deep offshore fields), and a higher supply base. This complicates the task of ensuring the right level of upstream oil and gas investment over time to meet evolving demand. Underinvestment would result in much higher and more volatile prices, while overinvestment would mean projects face major commercial risks with potentially wider economic effects, including for the fiscal position of producer economies.

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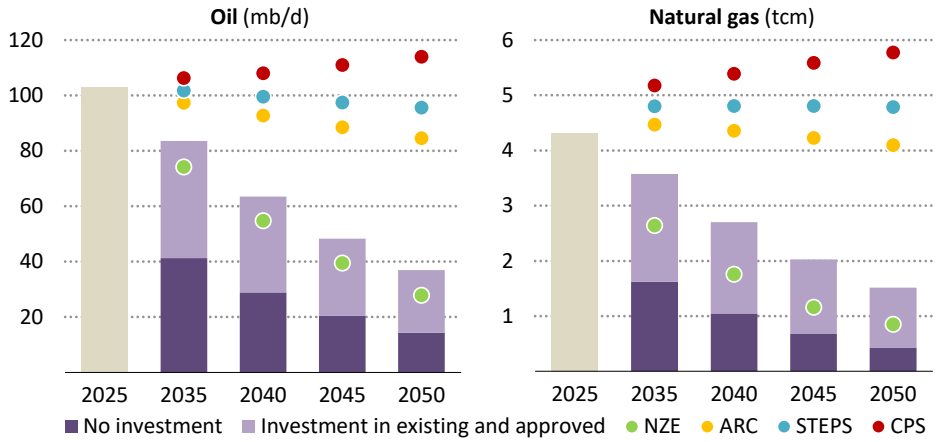
Figure 7.5 ▷ Global oil and gas production and demand by scenario, 2025-2050



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Natural declines make ongoing upstream investment essential, although care is needed to manage both under- and overinvestment risks

Notes: mb/d = million barrels per day; tcm = trillion cubic metres. Investment in existing unconventional oil and gas projects based on the NZE Scenario. Approved = conventional projects that have reached a final investment decision as of 2026.

In the STEPS, annual upstream investment averages USD 580 billion globally over the period to 2035, with USD 150 billion directed towards bringing online 24 million barrels per day (mb/d) of new conventional oil supply and 1 400 billion cubic metres (bcm) of new conventional gas supply (Figure 7.6). Some of the remainder is directed towards tight oil and shale gas, and some goes to slowing declines at existing fields, including through infill drilling of both vertical and horizontal wells, pumping and lifting, large-scale injections such as water flooding, and the deployment of enhanced recovery techniques.

In the CPS, upstream investment averages USD 640 billion each year to 2035. This is higher than in the STEPS – partly because of higher demand, but also because the additional resources are, in aggregate, higher-cost sources of supply that in many cases require new supporting infrastructure. Prices in the CPS are also higher than in the other scenarios; this feeds through to upstream cost inflation, which makes resource developments costlier.

In the ARC, importers introduce a range of measures to boost domestic production, such as lowering tax rates, increasing spending on exploration, and improving the regulatory environment. This is more costly than a system that relies more heavily on energy imports, but importing countries regard some additional cost as a price worth paying to minimise reliance on international markets and improve energy security. Total average annual upstream investment to 2035 is around USD 560 billion, with average investment by importers around 10% (or USD 10 billion) higher than in the STEPS.

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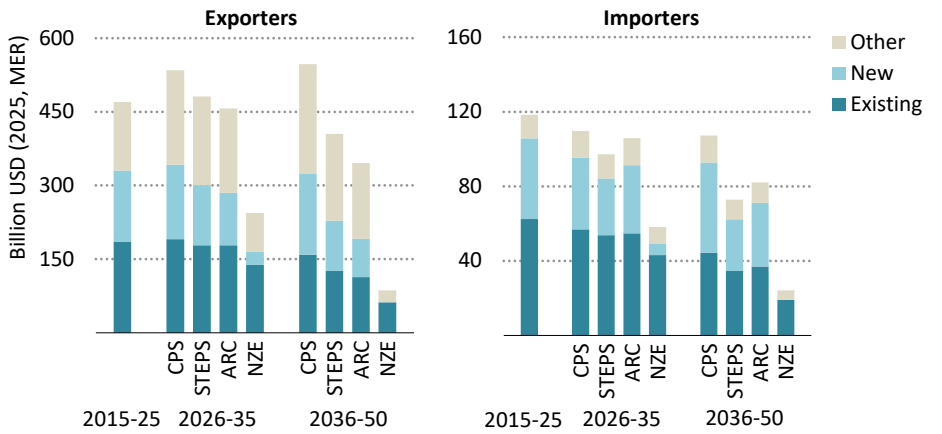
In the NZE Scenario, oil and gas demand declines by around 4% each year over the next ten years and then by 7% per year to 2050. This trajectory means that no new long lead-time conventional oil and gas projects need to be approved for development, and it implies the shutting-in of some existing production. Even in this scenario, around 30 mb/d of residual oil demand remains in 2050, mainly for use as petrochemical feedstock, as well as 850 bcm of residual natural gas demand, used mainly for chemicals and residual power sector inputs. It follows that investment in some existing fields and fossil fuel infrastructure continues to be necessary throughout energy transitions.

Figure 7.6 ▷ Average annual upstream oil and gas investment by scenario, 2015-2050



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Upstream investment varies by scenario, reflecting demand levels and resource costs as well as importer efforts to boost domestic production and reduce import dependence

Notes: MER = market exchange rate. Other includes tight oil and shale gas. New field investment in the NZE Scenario is for projects that are currently under construction or those that are approved before the end of 2026.

Oil and gas import dependence

High oil and gas import dependence can leave countries vulnerable to geopolitical tensions, infrastructure disruptions and market volatility. A key route for countries and regions to reduce this dependence is to cut demand for oil and gas, for example by introducing measures to boost electrification and improve energy efficiency (Figure 7.7). In the CPS, Japan and Korea consume almost 5 mb/d of oil in 2050, nearly all of which is imported; in the ARC, this number is reduced to around 3 mb/d as a result of concerted efforts to electrify end-uses, diversify fuels and improve vehicle efficiency. Reducing imports brings important benefits for energy security, although it can create challenges elsewhere in the system (see sections on electricity and critical minerals, below) and governments need to be watchful of

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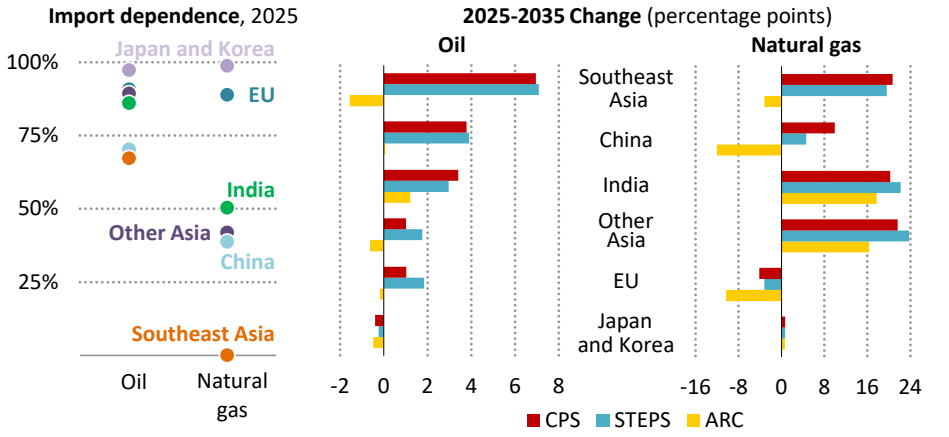
the effects on the commercial operation of refineries, pipelines, storage facilities and import terminals that remain important for security of supply.

Some importers have scope to increase domestic fossil fuel production in order to reduce imports, but in general, the potential is outweighed by opportunities to cut demand through efficiency, electrification and the use of alternative low-emissions fuels. In the CPS, most importers are already producing close to the maximum level possible given resource and cost constraints, making it challenging to boost production further. In the ARC, net importers increase domestic production compared to the STEPS, but the overall impact on imports is relatively muted. For example, EU oil imports fall from 10 mb/d today to 3.5 mb/d in 2050 in the STEPS and to 2 mb/d in 2050 in the ARC. The 1.5 mb/d difference is almost entirely due to lower demand (95%) rather than increased domestic production (5%).

Figure 7.7 ▷ Net oil and gas import dependence and change in selected regions by scenario, 2025-2035



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Oil and especially gas import dependence rises in most countries in the CPS and STEPS, but targeted action could curb or avoid these increases

7.3.2 Diversity

Oil and gas imports

A diverse mix of oil and gas suppliers can reduce the importance of any single exporting country or region in importers' supply portfolios, and it can also make it easier to adjust procurement when policy preferences or market conditions shift.

In the CPS and STEPS, countries in Asia rely on the Middle East for around 45% of their imported oil and gas in 2035 (down from above 50% today). In the ARC, most importers diversify their imports (Figure 7.8), with the share of the Middle East in Asia's oil and gas imports dropping to 40% in 2035.

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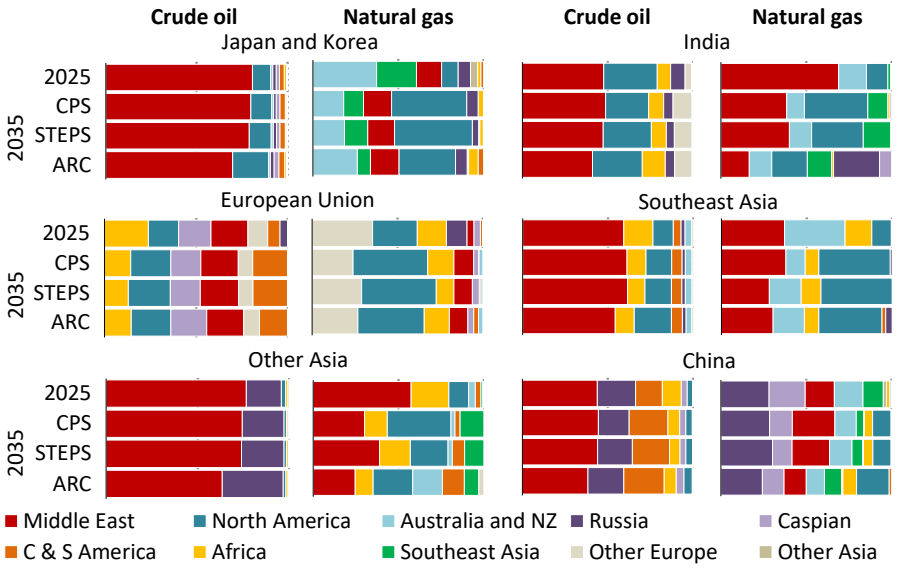
Figure 7.8 ▷ Crude oil and natural gas import shares by origin and scenario, 2025 and 2035



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Today, supply sources are generally more concentrated for importers of oil than for gas; in the CPS and the STEPS, the concentration stagnates for oil but declines for gas

Fuel diversification is about routes as well as suppliers. Exporters as well as importers have an interest in diversifying routes to key markets. Exporters also have a more general interest in economic diversification away from heavy reliance on fuel exports. In recent years, many producers have announced plans to promote more resilient economies; some have adopted roadmaps for diversification, such as Vision 2030 in Saudi Arabia, while others have focused on reforms to smooth spending cycles, such as the decision by the United Arab Emirates to promote multi-year budgeting from 2017.

Oil product import dependence and domestic refining capacity

Import dependence for individual oil products varies widely between countries (Figure 7.9). In most importing countries and regions, the import dependence of the oil product that is most heavily imported today tends to remain high in the CPS and STEPS through to 2035, and in some cases, it even increases. Countries with falling total oil demand, for example Australia, Japan and countries in the European Union, may intervene to underpin refinery operation (as Australia does with its Fuel Security Services Payment) and refineries can invest to better match output with changes in product demand, but the supply-side options to avoid importing oil products are typically limited. In countries that are heavily reliant on liquefied petroleum gas (LPG) imports, there is likely to be little economic rationale for new refineries to produce LPG, even with increases in overall demand for LPG to 2035, because LPG is

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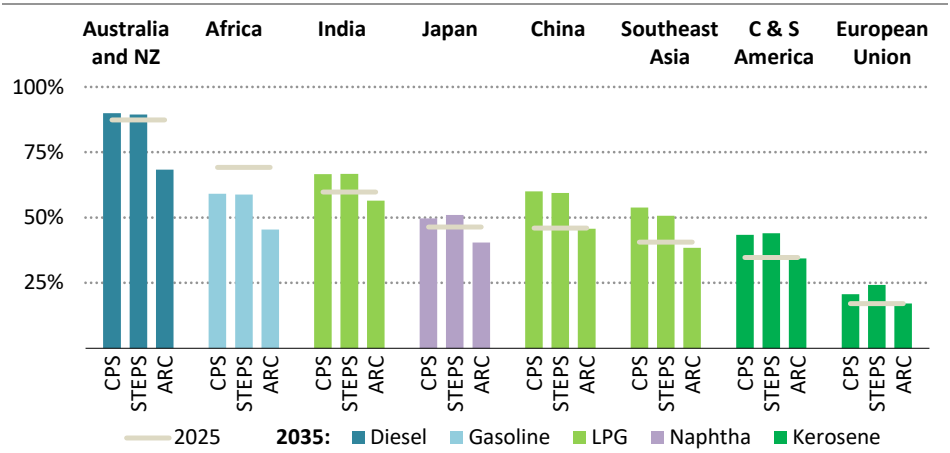
generally a low-value product for refiners. In such contexts, stockpiling is likely to be worth serious consideration as an option for strengthening security.

Figure 7.9 ▷ Import dependence for selected oil products by region and scenario, 2025 and 2035



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Import dependence for key oil products remains high in the CPS and STEPS; it could be reduced, as in the ARC, but this would increase costs and crude oil imports

Notes: LPG = liquefied petroleum gas. Import dependence is defined as the ratio of net imports to local demand for LPG, kerosene, naphtha, diesel or gasoline, including demand for international bunkers.

Refining capacity rises from 106 mb/d in 2025 to 110 mb/d by 2035 in the CPS and 108 mb/d in the STEPS. In both scenarios, capacity additions are concentrated in sub-Saharan Africa, India and the Middle East. Capacity expansions in India and the Middle East are primarily geared towards export markets, and those in sub-Saharan Africa towards the regional market. Despite a doubling in refining capacity, sub-Saharan Africa remains a net importer of oil products, with net imports contracting from 1.8 mb/d today to 1.2 mb/d by 2035. Product trade rises by around 20% by 2035 in the CPS, ten percentage points more than in the STEPS. In the ARC, oil product import dependence drops materially across all regions. This requires around 5 mb/d of new refinery capacity to be built in regions that are net importers of oil products (compared with 3 mb/d in the STEPS), alongside 8 mb/d of refinery upgrades and modifications (around 4 mb/d in the STEPS). This adds to the global cost of refining (Chapter 5).

7.3.3 Flexibility

Oil and gas flows through chokepoints

The 2026 energy crisis has provided a stark reminder of the persistent energy security risks posed by maritime chokepoints. Many narrow transit routes carry large volumes of oil, gas

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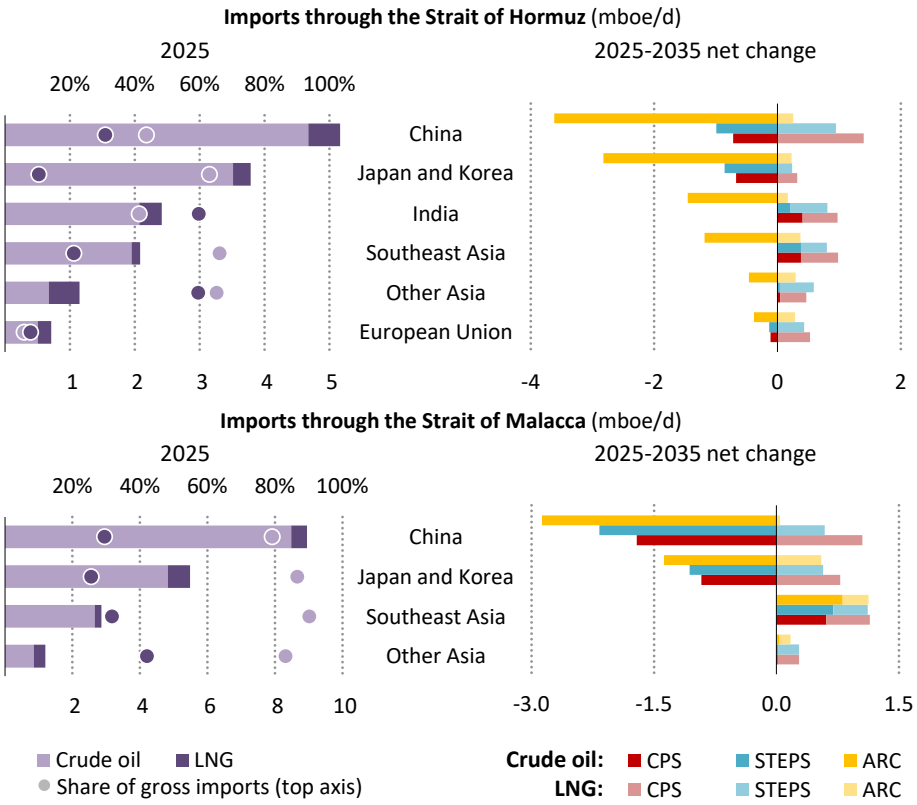
and other energy commodities. They include the Danish Straits, the Turkish Straits, the Strait of Gibraltar, the Suez Canal, the Panama Canal and the Bab el-Mandeb Strait (which has seen increased security risks from Houthi activity). The two most prominent by volume are the Strait of Hormuz and the Strait of Malacca. As shown in 2026, the availability of bypass capacity for a chokepoint can be a vital energy security asset but typically requires some public support or regional cost-sharing; the commercial returns on infrequently used infrastructure may not reflect the full security value.

Figure 7.10 ▷ Imports and share of gross imports through the Straits of Hormuz and Malacca by scenario, 2025 and 2035



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Dependence on the Straits of Hormuz and Malacca for LNG rises in the CPS and STEPS; oil flows through Hormuz fall by over 10 mb/d in the ARC and 18 mb/d in the LHC by 2035

Note: mboe/d = million barrels of oil equivalent per day; LNG = liquefied natural gas; LHC = Low Hormuz Case.

Sources: IEA analysis based on data from ICIS (2026); Kpler (2026); US EIA (2026).

In 2025, over 20 mb/d of oil and 110 bcm of LNG passed through the Strait of Hormuz. This was equivalent to about 25% of global seaborne oil trade and 20% of LNG trade, although

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dependence is much higher for some countries (Figure 7.10). Oil flows through the waterway remain steady in the CPS and in the STEPS to 2035, and they fall by more than 10 mb/d in the ARC. In the LHC, only around 2 mb/d of oil flows through the Strait of Hormuz in 2035. The difference between the STEPS and the LHC stems from increased flows through bypass routes (65%), lower demand in importers (20%) and increased production in countries outside the Middle East (15%).

The Strait of Malacca is a stretch of water between Indonesia and Malaysia that connects exporters in Africa and the Middle East with Asian importers and is an important location for fuel storage, blending and ship refuelling. Around 23 mb/d of oil and 95 bcm of LNG currently pass through the Strait of Malacca. In the CPS and STEPS, oil flows marginally increase, while LNG flows rise to 200-250 bcm in 2035 as gas demand increases across Asia. In the ARC, efforts to limit import needs mean that oil flows fall to around 20 mb/d in 2035, while LNG flows rise more slowly, reaching 175 bcm.

Although the impact of a disruption is unlikely to be as severe as in the Strait of Hormuz, the narrowness of the Strait of Malacca creates some risks of congestion, collisions or other disruptive incidents, with potential implications for regional oil and LNG trade. Alternative routes are limited: the Sunda Strait in Indonesia is too shallow and narrow for large oil vessels, while the wider and deeper Lombok Strait, also in Indonesia, is constrained by sparse port and refuelling infrastructure. Any diversion would increase voyage times between Asia and the Middle East, causing delays and adding costs.

Oil storage and stockholding

Oil inventories are an integral part of supply chains. They are also held for emergency purposes to provide a buffer against unexpected disruptions. Their availability varies widely by country. Around 8.3 billion barrels were held in observed oil inventories worldwide in February 2026 – the highest level since February 2021. Roughly half of this total was held in advanced economies in the form of both industry and government stocks, and the majority consisted of crude oil rather than oil products. Following significant stock building in 2025, China was estimated to hold more than 1.3 billion barrels of crude oil in tanks. The amounts of oil products held in emerging market and developing economies cannot be assessed easily by satellite, are not routinely reported and are not included in observed inventory levels.

The 8.3 billion barrels in storage prior to the 2026 energy crisis should in theory satisfy global oil consumption for 80 days. However, the amount by which stocks could fall before parts of the oil supply system would come under operational strain is in practice far smaller because a minimum level of working stocks is required to operate refineries, terminals and logistical networks.

During the 2026 energy crisis, governments and industry alike have tapped into oil inventories to mitigate the immediate impact of supply disruptions. In total, observed global stocks fell by around 460 million barrels between March 2026 and the end of October 2026. This decline includes commercial stock draws as well as releases made as part of the collective action by IEA Member countries to make 400 million barrels from emergency

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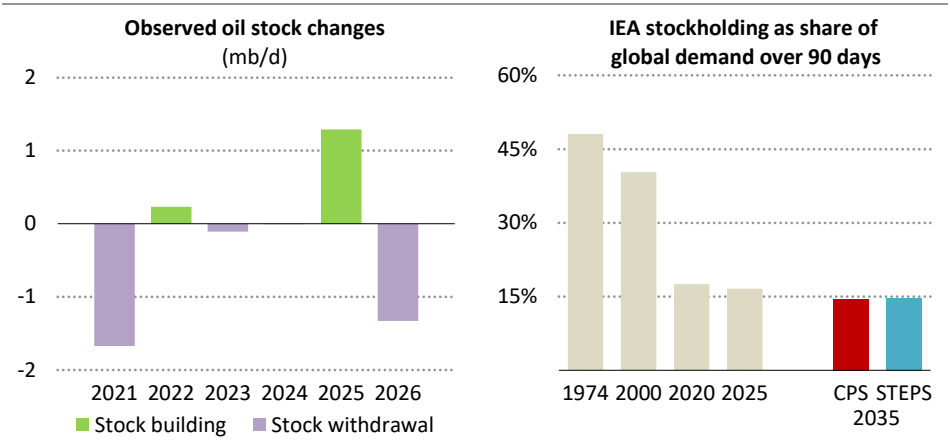
stocks available to the market. The crisis has highlighted the importance of the location and accessibility of stocks, the split between crude and different products, their quality and specifications, and countries' willingness to tap them.

Emergency oil stockholding will remain an essential source of flexibility for global energy systems. As highlighted by the IEA's 2026 collective action, stocks provide reassurance to market participants that supplies can be made available if needed; this can dampen market reactions and reduce the level of damaging price spikes. These buffers are most effective when underpinned by institutional capacity to monitor markets and act quickly to forge agreement on the measures needed in the event of supply disruptions.

Future changes in oil demand will inevitably have implications for oil emergency stockholding systems. In the CPS, overall global demand for oil rises to 2035, while demand falls in many countries that are IEA Members and have stockholding obligations. The stockholding obligation of IEA Member countries represented more than 40 days of global oil demand when the IEA was founded in 1974. In the STEPS, the changes that have taken place since 1974 mean the amount of oil represented by the stockholding obligation of current IEA Member countries would cover just 13 days of global consumption by 2035 (Figure 7.11). This is a strong argument in favour of expanded co-operation on oil stockholding and emergency response systems, involving a wider range of emerging market and developing economies.

Figure 7.11 ▷ Historical oil stock changes and IEA stockholding obligation as a share of global demand over 90 days



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Falling demand in advanced economies and growth in emerging market and developing economies mean IEA stockholding obligations cover 13 days of global oil demand by 2035

Notes: 2026 = January-October. IEA stockholding obligation is taken as 90 days of net imports; in practice, most IEA Member countries have stockholding that can cover more than 90 days of net imports.

Source: Oil Market Report November (IEA, 2026a).

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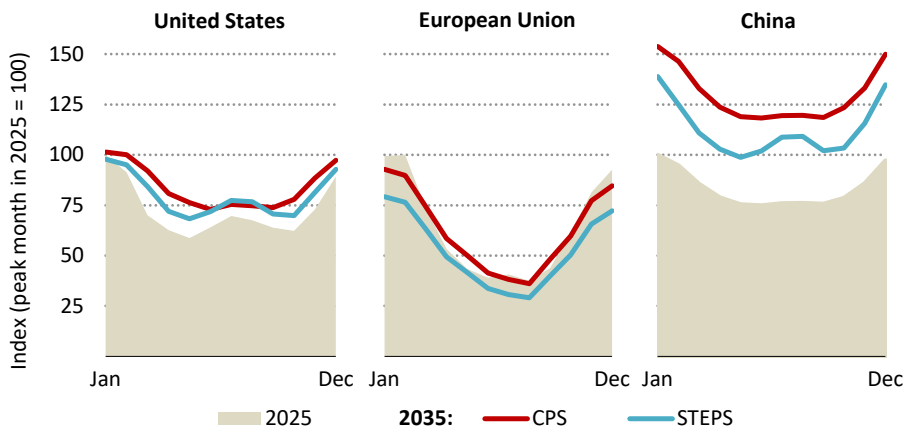
Gas storage

In regions with substantial heating needs, gas demand is highly seasonal, while production and import infrastructure typically operates more steadily throughout the year (Figure 7.12). A higher share of gas use for building heating and non-baseload power generation increases the sensitivity of demand to temperature, widening the gap between peak and average gas demand. Storage allows gas to be injected during low-demand periods and withdrawn during peak demand periods, and it has an important part to play in managing seasonal variations in demand. It also provides flexibility in case of supply disruptions, extreme weather or other instigators of market volatility. Many regions and countries have underground gas storage arrangements in place: the United States has the largest (around 135 bcm, or 15% of average annual consumption), and the European Union the second largest (around 105 bcm, or a third of average annual consumption).

Figure 7.12 ▷ Normalised monthly natural gas demand profiles by selected region and scenario, 2025 and 2035



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The United States, the European Union and China have extensive gas storage or flexibility mechanisms to manage strong seasonal demand swings

Notes: Monthly demand is normalised for the number of days in each month. The 2035 values represent an average year without extreme temperatures.

Sources: United States: US EIA (2025); European Union: Eurostat (2025); China: JODI (2025).

EU countries have been operating gas storage facilities for many years to manage additional demand for gas in winter. Peak monthly gas demand in the European Union over the past five years was around 1.6 times the average monthly level. The importance of storage increased after the 2022 crisis that followed Russia's full-scale invasion of Ukraine, with storage-filling obligations becoming a core element of EU energy security policy. EU gas demand falls in all scenarios, but declines in sectors with strong seasonal variations are slightly higher in the CPS, reducing the ratio of peak to average demand. In the NZE Scenario,

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some regions see higher peak demand ratios, but lower overall consumption softens the absolute seasonal swing.

China's gas demand has expanded rapidly, and investments in storage have also picked up pace in recent years. Current underground storage capacity is around 30 bcm, or almost 10% of average annual gas consumption, and is complemented by significant above-ground storage in LNG tanks. With weather-sensitive gas demand set to grow strongly, further storage could play a helpful part in managing seasonal fluctuations and strengthening energy security.

Other regions also experience large seasonal changes in gas demand, but they manage them through alternative mechanisms. For example, Japan and Korea import LNG from a diverse range of sources, have substantial regasification capacity and hold LNG inventories at import terminals. Japan also has a strategic LNG buffer framework in place, under which the government compensates a designated private operator for the cost of holding surplus LNG cargoes for emergency use. In tropical regions, including much of Southeast Asia, there is limited seasonal variation in gas demand since low levels of gas are used for residential heating. This limited variation reduces the need for storage facilities.

Gas infrastructure

Gas grids in well-established markets can provide a critical source of system flexibility during winter, but this strength is also a vulnerability as it amplifies the risk posed by outages to large transmission pipelines, LNG terminals or storage infrastructure.

Mitigating this risk, especially in regions and scenarios with rising gas demand, requires continued investment in maintaining existing assets and developing new gas infrastructure, taking account of the need for adequate spare capacity, alternative routes and operational flexibility. In the CPS and STEPS, most investment is needed to maintain existing transmission and distribution pipelines in established markets. Strong demand growth in the CPS requires new pipelines and additional LNG infrastructure in importing regions, including China and Southeast Asia, and in exporting regions, including the Middle East and North America.

The costs of maintenance and replacement investment in gas infrastructure depend on capacity rather than throughput. This means that the cost of each unit of gas delivered can rise in regions with falling gas demand. In the ARC, for example, aggregate gas demand in importing regions falls by nearly 10% to 2035, while the length of maintained gas networks increases by more than 5% (Figure 7.13). While electrification can improve many aspects of fuel security, a progressive move away from gas use risks leaving a smaller customer base to support gas infrastructure. If the least affluent face financial barriers to electrification, this smaller base could contain a disproportionate share of those who are least well-off. This underlines the need for careful planning for transitions from gas.

The ability to use existing gas infrastructure can also help to lower the costs of developing and supplying low-emissions gases, thereby expanding domestic supply and reducing fossil fuel imports. Biomethane is a particularly attractive option because it can be injected directly

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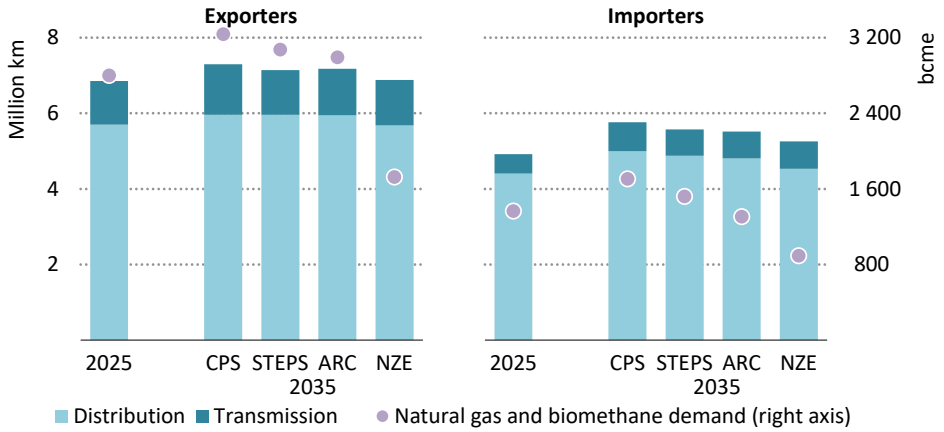
into existing gas networks and supply the equivalent of more than 20% of today's global gas demand from sustainable feedstocks (IEA, 2025b). In the CPS, close to 1% of gas injected into grids is biomethane in 2035; this rises to nearly 1.5% in the STEPS and to 2.5% in the ARC. Low-emissions hydrogen can also be blended into gas grids, up to a certain limit.

Figure 7.13 ▷ Installed length of gas networks and gas demand by scenario, 2025 and 2035



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Investment to maintain gas infrastructure remains essential across scenarios, even in countries or regions with declining gas demand

Notes: km = kilometre; bcme = billion cubic metres of natural gas equivalent.

Spare capacity

Among the Organization of the Petroleum Exporting Countries (OPEC), spare capacity – the volume of crude oil production that can be brought to market relatively quickly from existing fields and facilities, over and above current production levels – stood at around 4 mb/d at the end of 2025, including the United Arab Emirates. This spare capacity acts as a buffer against supply disruptions, unexpected demand growth and geopolitical shocks, helping to reduce the risk of acute market shortages and sharp price spikes. However, effective spare capacity has fallen considerably with the withdrawal of the United Arab Emirates from OPEC in May 2026, and nearly all of it was blocked off during the 2026 energy crisis.

There is no other similar mechanism of comparable size in non-OPEC oil markets. Most conventional sources of supply take years to ramp up. The source of supply that can react fastest – US tight oil production – is structurally very different, with production dispersed across thousands of private operators who respond to price signals through changes in drilling and investment activity. Meanwhile, among OPEC countries, spare capacity is concentrated in a small number of producers who can take decisions more easily over production levels.

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Over the past five years, current members of OPEC have provided spare crude oil capacity of around 3-4% of global crude oil supply. In the years ahead, the strength of demand growth, the cohesion and breadth of OPEC membership, the extent of upstream investment, and the quality of asset management in key countries and fields will all influence the group's spare capacity levels. There is likely to be a greater focus on deliverability of this capacity, given the experience with the interruption of flows through the Strait of Hormuz in 2026.

Oil demand in the CPS means that, if OPEC's spare crude oil capacity is to return to 4% of global crude oil supply out to 2035, members would need to develop nearly 4.5 mb/d of additional crude oil supply capacity over and above the 30 mb/d of crude oil they produce for immediate use in that year. This would require on average around USD 20 billion of investment each year to 2035 (compared with average annual upstream investment of about USD 90 billion among OPEC members in the CPS), which translates into around USD 0.7/bbl of production in 2035. In the STEPS, lower demand and a lower level of production from members of OPEC mean that investment in the group's spare crude oil capacity is reduced by around USD 1 billion per year. Less dedicated upstream investment would be required in the LHC, although investment would be needed in additional infrastructure that bypasses the Strait of Hormuz.

7.4 Electricity security

Electricity already supports over 45% of global economic activity, and this share is set to rise to around 55% by 2035 in all scenarios (IEA, 2026b). As electricity systems evolve, new electricity security challenges are emerging. Addressing these challenges requires co-ordinated planning and investment across markets, operations, infrastructure and technologies. This section considers what rapid changes in electricity systems mean for adequacy, flexibility, robustness and diversity of supply.

7.4.1 Adequacy

Adequacy is the ability of the power system to meet demand at all times. Since electricity supply and demand must be balanced instantaneously, adequacy is typically assessed against peak demand. Peak electricity demand reflects consumption patterns as well as overall growth in demand, which is driven by higher economic activity, industrialisation, urbanisation and digitalisation. Peaks typically occur during the hottest or coldest periods of the year, when large numbers of cooling or heating appliances run simultaneously. Electrification, extreme weather events, growing shares of variable renewables and shifting consumption patterns are already reshaping demand profiles, resulting in increased variability and higher peak demand. This trend is set to continue, calling for careful attention to ensure that sufficient resources are available to meet demand reliably.

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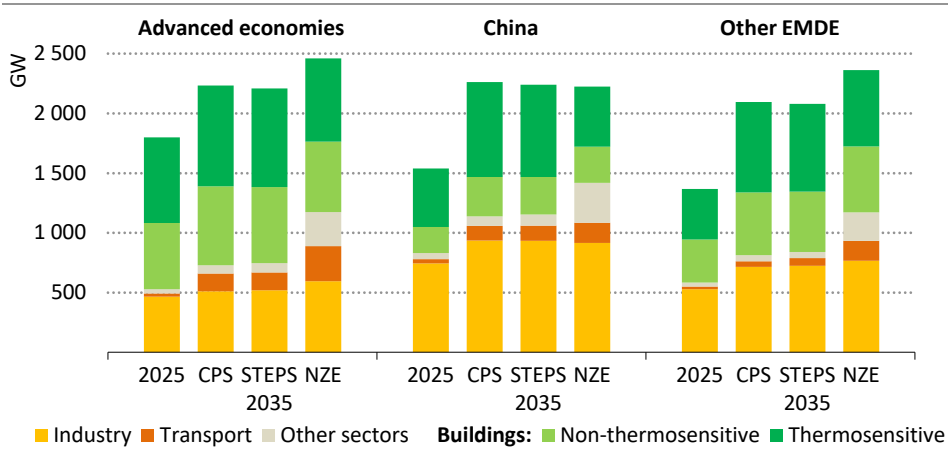
Peak electricity demand is 4 700 gigawatts (GW) across markets today, and this grows by about 40%[2] in the CPS and STEPS to 2035, outpacing overall electricity demand growth (Figure 7.14). In the NZE Scenario, peak electricity demand grows by 50% across markets by 2035 due to rapid electrification. Regional and end-use trends reveal larger differences between the scenarios. In advanced economies, peak demand is over 10% higher in 2035 in the NZE Scenario than in the STEPS because of the faster progress made in the former in electrifying end-uses in heating, transport and industry. In end-uses, peak demand for cooling grows by 720 GW in the CPS – more than the entire generation capacity of India today – as limited efficiency gains drive cooling demand higher. In the NZE Scenario, by contrast, the electrification of transport and heating shifts peaks away from the main cooling hours, and efficiency gains further reduce the contribution of cooling to peak demand.

Figure 7.14 ▷ Peak electricity demand by region, end-use and scenario, 2025 and 2035



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Peak demand is set to grow by 40% globally by 2035 in the STEPS and CPS and by 50% in the NZE Scenario, in which stronger electrification offsets stronger efficiency gains

Notes: GW = gigawatt. EMDE = emerging market and developing economies. Peak demand is the average level of demand for the 100 hours of the year with the highest demand.

The underlying structure of electricity demand can lead to different risks to adequacy, along with opportunities to increase adequacy. Across scenarios, for example, higher cooling demand increases the sensitivity of peak demand to heat waves and potentially cuts into power system margins, while higher electrification of transport drives evening peaks in demand, and the growing use of heat pumps increases electricity demand in winter. However, there are opportunities to temper increases in cooling demand through more efficient cooling equipment, to shift part or most of the evening loads to periods of high

[2] This represents the sum of individual peaks across electricity systems globally.

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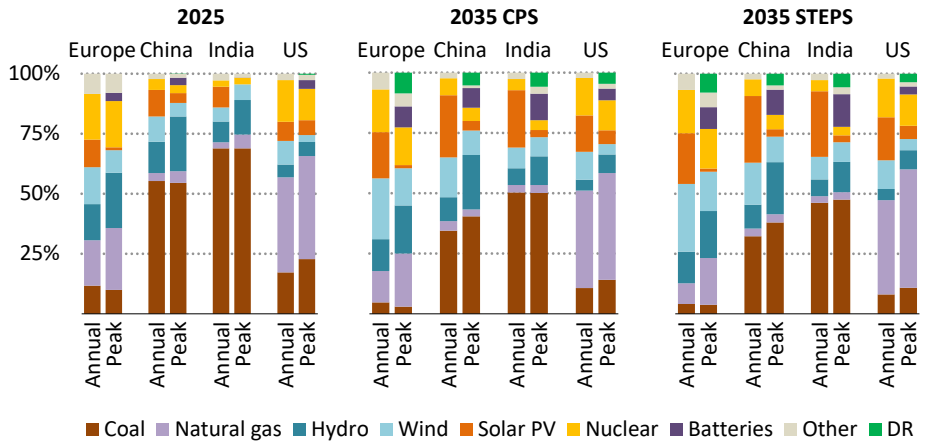
renewable generation through smart charging, and to manage increased winter heating demand through dynamic prices, smart equipment and changes to market structures. None of these responses constitutes a silver bullet, but they all help manage growing vulnerabilities.

Figure 7.15 ▷ Annual and peak residual load hour supply mix in Europe, China, India and the United States in the CPS and STEPS, 2025 and 2035



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Thermal power plants and hydro remain central during peak residual load hours, while batteries and demand response meet a growing share of adequacy needs by 2035

Notes: US = United States. DR = demand response. Other includes bioenergy, marine, geothermal, concentrating solar power, oil, non-renewable waste and other sources. Peak residual load hours are defined as the 100 hours when electricity demand net of available wind and solar photovoltaics (PV) generation is highest.

In systems characterised by high shares of variable renewables, electricity adequacy needs to be assessed against periods of peak residual load as well as peak demand.[3] Dispatchable power capacity, storage and demand response can all help systems to manage when low renewables output coincides with periods of high demand. Batteries are set to play an increasingly important role in this respect. Total global installed dispatchable generating capacity grows from 7 000 GW in 2025 to around 8 400 GW in the CPS, 8 200 GW in the STEPS and 7 200 GW in the NZE Scenario by 2035. Global installed battery storage capacity rises from nearly 300 GW in 2025 to nearly 1 800 GW in the CPS, over 2 100 GW in the STEPS and more than 3 300 GW in the NZE Scenario by 2035. Today, coal provides the largest share of supply during peak residual load hours in China and India, while natural gas and nuclear power play more important roles in Europe and the United States. These technologies remain

[3] Peak residual load refers to the 100 hours with the highest residual load over the year, where residual load is hourly demand minus available generation from variable renewables, before curtailment.

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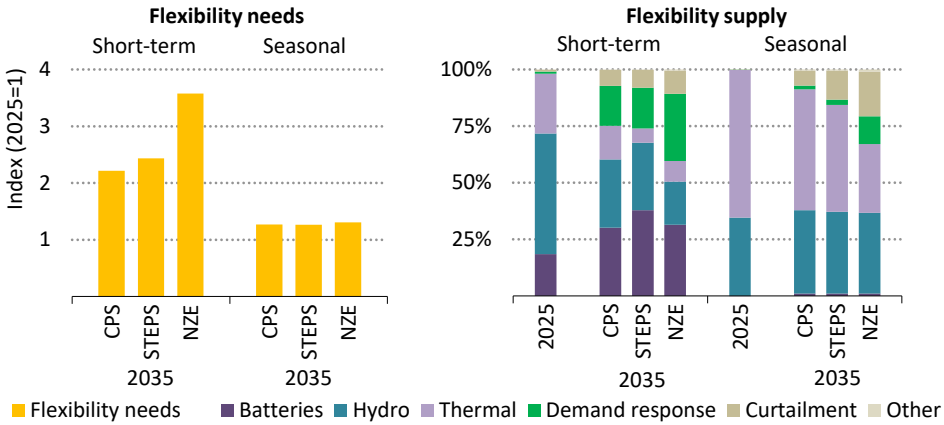
important in 2035 in both the STEPS and the CPS, but battery storage and demand response cover a growing share of adequacy needs, and together they meet around 10-15% of peak residual load in all four regions in both scenarios (Figure 7.15).

7.4.2 Flexibility

Flexibility is the ability of an electricity system to balance supply and demand across all timescales. Flexibility needs increase substantially in all scenarios as electricity demand grows and the share of variable renewables rises. Short-term flexibility is necessary to manage changes in supply and demand within and between days (i.e. hour-to-hour), while seasonal flexibility addresses imbalances over longer periods. The scale and drivers of these needs differ across regions, reflecting variations in the uptake of solar photovoltaics (PV) and wind, in the electrification of heating and cooling, and in the efficiency of electricity-consuming equipment (Box 7.2).

Figure 7.16 ▷ Global short-term and seasonal flexibility needs and supply in the CPS, STEPS and NZE Scenario, 2025 and 2035



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Higher shares of variable renewables and evolving electricity demand patterns increase flexibility needs; batteries and demand response emerge as key sources of flexibility

Notes: Other includes concentrating solar power, geothermal, marine and other sources. Short-term flexibility needs are calculated as the average hourly ramp of the residual load over the top 100 hours with the highest upward ramps, divided by the average hourly electricity demand for the year. Seasonal flexibility needs are assessed by computing the absolute difference between the weekly and annual averages of the residual load, divided by the annual electricity demand.

Global short-term flexibility needs rise to around two to two-and-a-half times their 2025 level in the CPS and STEPS to 2035, with a slightly larger increase in the STEPS because it sees a higher level of solar PV generation. The increase is even stronger in the NZE Scenario, in which global short-term flexibility needs rise to over three-and-a-half times their 2025 level

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(Figure 7.16). This effect is particularly pronounced in India, where large additions of solar PV push short-term flexibility needs to nearly three times their 2025 level in the CPS and almost three-and-a-half times in the STEPS. In China, short-term flexibility needs rise to two-and-a-half times their 2025 level in the STEPS and more than double in the CPS; in Europe, they roughly double in both scenarios, while in the United States, they increase by around 60% in the CPS and double in the STEPS.

Seasonal flexibility needs are shaped by longer-lasting variations in temperature-sensitive demand and weather-dependent generation. They rise globally by an average of around 25% until 2035 in the CPS and STEPS and by 30% in the NZE Scenario. In Europe, for example, the electrification of heating increases temperature-sensitive winter electricity demand. In China and India, rising cooling demand has a similar effect in the summer. Seasonal flexibility needs in China and Europe are higher in the STEPS than in the CPS, reflecting higher levels of electrification and variable renewable generation. In India, they are lower in the STEPS than in the CPS, despite similar levels of electrification, because the STEPS sees faster adoption of more efficient appliances that moderate variations in electricity demand. Beyond regular seasonal patterns, the most demanding periods for power systems are spells of low wind and solar output lasting several days or weeks, especially when they coincide with periods of high demand such as cold, still winter weeks in Europe (IEA, 2024). The possibility of dry years that reduce hydro output also strongly affects flexibility needs (IEA, 2023a).

The sources of flexibility are also set to change. Today, hydropower and thermal power plants provide most short-term flexibility and almost all seasonal flexibility. Hydropower's contribution depends on water availability, which varies from year to year and is affected by changing rainfall patterns (see section 7.6). The contribution of both sources continues to grow in absolute terms, but their combined share of global short-term flexibility falls by 2035 as alternative sources expand much faster. This share drops to around 45% in the CPS, 35% in the STEPS and 30% in the NZE Scenario. Batteries, including both grid-scale and behind-the-meter systems, grow to account for around 30% of short-term flexibility needs in the CPS and 40% in the STEPS, and demand response for around a further 20% in both scenarios. In the NZE Scenario, the two sources together supply 60% of the short-term flexibility required in 2035. Batteries are well suited to shifting electricity within the day; demand response moves consumption to periods of abundant supply.

The global seasonal flexibility supply mix changes more slowly. Hydropower and thermal power plants together provide around 90% of seasonal flexibility in the CPS, 80% in the STEPS and around two-thirds in the NZE Scenario in 2035, reflecting their ability to manage seasonal variations in demand or the supply of variable renewables. Renewables curtailment accounts for around 5% of global seasonal flexibility in 2035 in the CPS, nearly 15% in the STEPS and 20% in the NZE Scenario; accepting some unused generation can be more economic than building enough storage or network capacity to absorb all surplus output. Grids and interconnections support power system flexibility across all timescales by allowing variations in supply and demand to be balanced over wider areas.

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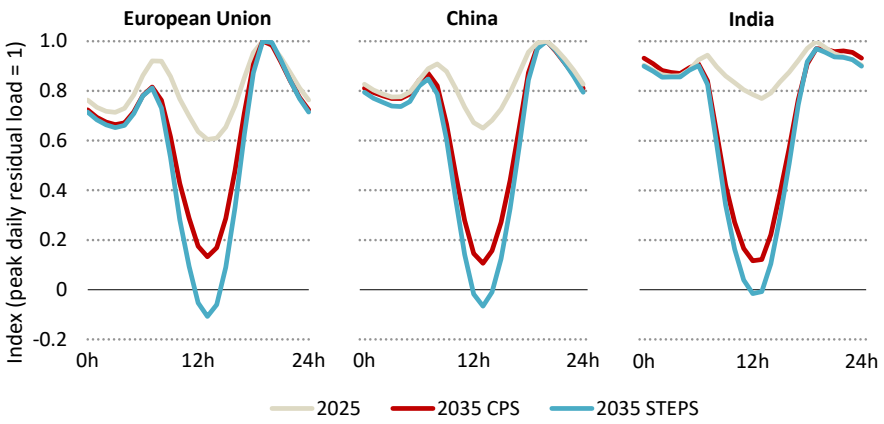
Box 7.2 ▷ Sun at midday: the residual load dip across the world

Solar PV generation peaks at midday and declines to zero at night. By contrast, demand in most regions grows through the morning, reaches a high point around midday and peaks in the evening just when solar PV generation declines the fastest. This imbalance between solar PV and demand patterns changes the shape of the residual load (i.e. net load) and drives short-term flexibility needs. Such residual load patterns are already visible across markets. On average over 2025, the residual load at midday was 35% lower than its evening peak in China, 40% lower in the European Union and 25% lower in India (Figure 7.17).

Figure 7.17 ▷ Average daily indexed residual load for the European Union, China and India in the CPS and STEPS, 2025 and 2035



By 2035, the average daily residual load becomes negative around midday in the STEPS as solar PV generation exceeds demand

Note: Residual load is calculated as demand minus available variable renewables (before the activation of any integration measure such as demand response or curtailment).

Across the world, demand growth combined with the rising use of solar PV reshapes the residual load in all scenarios. In the STEPS, the residual load becomes negative at midday on average over the year in China, the European Union and India by 2035. In the CPS, in which solar PV generation grows by 12% less than in the STEPS, the residual load at midday is 90% below its evening peak in all three regions. The ramp to the evening peak is increasingly steep, causing short-term flexibility needs to more than double in China and Europe and triple in India by 2035 in both the STEPS and the CPS compared to today.

This changing shape has implications for dispatchable plants, batteries and demand response. It strengthens the economic case for the deployment of battery storage; where storage represents a minor part of the system, other dispatchable technologies need to

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cycle more to integrate fully the available solar PV and wind. This increased cycling could require additional investment. The changing shape also creates opportunities to deploy time-of-use and dynamic tariffs to encourage consumers to shift demand. Realising the full potential of demand response requires action to remove regulatory barriers to market participation, strengthen consumer incentives and deploy smart technologies, including smart meters.

7.4.3 Robustness

The robustness of power systems is threatened by the potential vulnerability of electricity grids. Grid infrastructure is the physical backbone that connects generation to consumers, but in many systems, it is ageing, congested or expanding too slowly to keep pace with rising electricity demand, the growing deployment of variable renewables and changing patterns of electricity use. When grids are not well developed or well managed, an electricity system becomes more exposed to local outages, connection delays, congestion, renewables curtailment and higher costs. Conversely, more efficient use of existing networks could allow up to 330 GW of additional generation, storage and demand to connect without grid reinforcement (IEA, 2026c).

Action to expand and modernise grids is central to reducing this vulnerability. Grid planning needs to be integrated across generation, transmission, distribution and digital infrastructure, and it must precede or at least keep pace with electrification. Grid development projects often take 5 to 15 years, which means that planning is urgently needed today to enable grids to cope with electricity demand growth over the next two decades.

The challenge extends beyond adding network capacity. Legacy grids were designed around centralised, predictable generation and passive demand, and they are increasingly mismatched with variable renewables, bidirectional flows and concentrated loads. Around 16 million kilometres (km) of grid lines require replacement or major refurbishment by 2035, and a further 27 million km by 2050, with the most urgent ageing-related needs in advanced economies. In many emerging market and developing economies, the priority is to expand networks rapidly enough to serve growing demand and extend access without embedding new weaknesses.

Secure operation also requires careful attention to system stability. Traditional power plants use large rotating machines that naturally help the grid absorb disturbances and maintain voltage and frequency. Solar PV, wind turbines and battery storage typically do not automatically provide the same support. If their share increases, maintaining the grid within safe operating limits therefore increasingly depends on a portfolio of dedicated technologies, such as grid-forming converters and synchronous condensers. Monitoring, protection and control systems are also needed to co-ordinate their operation. Digitalisation and automation can improve system visibility, control and restoration, but they also increase vulnerability to cyberattacks – making security by design, information sharing and co-ordination among operators, equipment providers and public authorities essential.

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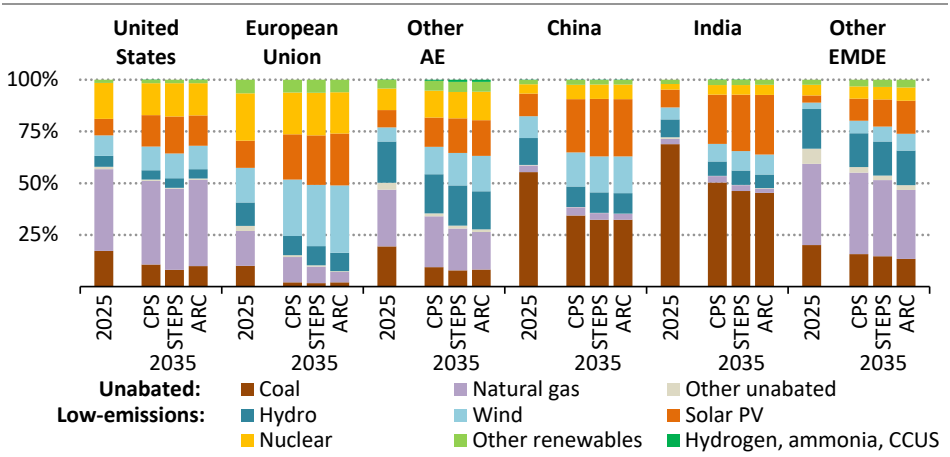
7.4.4 Diversity

Electricity generation mixes vary widely across regions, reflecting differences in resource endowments, infrastructure, policy choices and market design. This diversity matters for electricity security because each source of generation carries a different set of vulnerabilities. Among other sources, coal-, natural gas- and oil-fired power plants can provide dispatchable electricity, but their security profile depends heavily on whether fuels are produced domestically or imported, and on the diversity and reliability of suppliers, transport routes and storage. Renewables reduce exposure to fuel import disruptions once projects are built, but they are exposed to other risks, including weather dependency, manufacturing concentration and material availability. Nuclear power has a different profile as well: uranium and fuel services may be domestic or imported, but long refuelling cycles, which are typically around 18 months, mean that its short-term exposure to fuel supply disruptions is more limited than with fossil fuel plants. These distinctions make generation diversity a core feature of electricity security. They also mean that the benefits of any given mix of technologies need to be assessed from a comprehensive perspective; it is not enough simply to count how many technologies are present in the mix.

Figure 7.18 ▷ Electricity generation by source, region and scenario, 2025 and 2035



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Electricity mixes become more diverse in many regions by 2035; coal, natural gas, renewables and nuclear each support different dimensions of security

Notes: AE = advanced economies; CCUS = carbon capture, utilisation and storage. Other renewables include bioenergy and renewable waste, concentrating solar power, geothermal and marine. Other unabated includes oil, non-renewable waste and other sources.

The contribution of coal-fired power is largest in several major and fast-growing systems, including China, India and Southeast Asia, while natural gas plays a more significant role in many other emerging market and developing economies and the United States (Figure 7.18). Renewables already account for significant shares of supply in many regions, often

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combining large-scale hydro with growing contributions from solar PV and wind. By 2035, generation mixes become more diverse in many regions, but the direction and pace of change differ. In coal-heavy systems, the share of coal declines significantly in all scenarios as renewables expand and as nuclear power plays a larger role in some cases. In regions where natural gas is prominent today, gas shares tend to decline, as the combined contribution of renewables and nuclear increases, though the gas share holds steady in the United States. The security benefit of a more diverse generation mix is strongest when the diversification of sources of electricity is matched by the diversification of supply chains and sources of flexibility with robust infrastructure.

7.5 Critical mineral security

Critical minerals have moved to the forefront of the energy, economic and national security agenda in recent years. This reflects the growing strategic risks that countries face from supply concentration and expanding mineral trade restrictions. The number of mineral tariff codes subject to Chinese export controls has tripled since 2023, including major rare earth restrictions in 2025. Further controls with potentially major economic consequences were announced by China, but they are currently suspended until November 2026. Other countries also introduced new trade restrictions in 2025, including the Democratic Republic of the Congo (DRC) for cobalt, Mozambique for graphite and Zimbabwe for lithium. The recent proliferation of export controls has transformed concerns around high supply concentration from a theoretical vulnerability into an immediate energy and economic security challenge.

7.5.1 Robustness

These trends test the robustness of mineral supply systems. At present, a gap remains between expected supply from existing and announced projects and projected supply requirements across scenarios, even after taking account of increases in recycling rates (Figure 7.19). These gaps are particularly wide for copper and lithium, and supply deficits are expected to persist through to 2035, based on the current project pipeline. For copper, the projected 2035 gap in the STEPS has narrowed from around 30% in the *WEO-2025* STEPS to about 25%, helped by new projects in the DRC and Zambia. However, a projected supply gap has now emerged for cobalt as a result of the DRC's export quota, underscoring how policy shifts in major producers can quickly reshape the global supply outlook.

As the deployment of new energy technologies expands, access to the critical minerals needed to manufacture them is a growing vulnerability for energy systems. In the STEPS, lithium sees the strongest demand growth, more than doubling by 2035. Demand grows significantly for graphite (by around 60%), nickel (by around 45%), rare earth elements (by around 40%) and copper (by around 20%). The CPS involves slightly slower deployment of the technologies using critical minerals, but it still sees strong demand growth for all major energy minerals. Global demand in the ARC is broadly similar to its level in the STEPS, although its geographical distribution is different due to efforts to diversify technology manufacturing.

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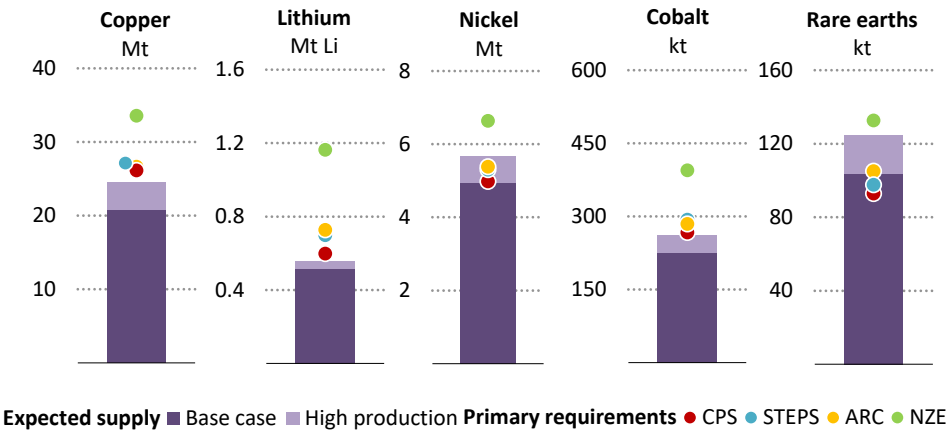
Figure 7.19 ▷ Primary supply requirements for critical minerals and expected supply from existing and announced projects by scenario, 2035



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Current project pipelines suggest that projected gaps between supply and demand will persist through to 2035

Notes: Mt = million tonnes; kt = kilotonnes; Mt Li = million tonnes of lithium metal content. Primary supply requirements are calculated as total demand net of secondary supply. The base case includes production from existing and under-construction assets, and projects with a high chance of moving forward. The high production case includes less certain projects at a reasonably advanced stage of development.

7.5.2 Diversity

Critical mineral supply chains remain highly concentrated, leaving import-dependent economies heavily exposed to disruptions in a small number of producing and processing countries. Mining supply shows some signs of diversification, although progress remains uneven across minerals. With the exception of nickel, the pipeline of announced projects offers some grounds for optimism that the geographic base of mining could broaden over time, but the effect is likely to be very limited. Since 2021, the IEA has tracked concentration using the combined share of the three largest producing countries. On average, these countries account for around 76% of global mine production today, and this share is projected to decline only modestly to 73% by 2035.

Refining is also highly concentrated, with China maintaining dominant positions across key energy minerals (Figure 7.20). China currently accounts for just under half of global copper refining output, around 75% of lithium and cobalt refining, 85% of magnet rare earth separation and over 95% of battery-grade graphite production. Concentration in rare earths and lithium could decline as new projects advance, but concentration remains entrenched for copper, nickel, cobalt and graphite, for which capacity expansion outside dominant suppliers is slower.

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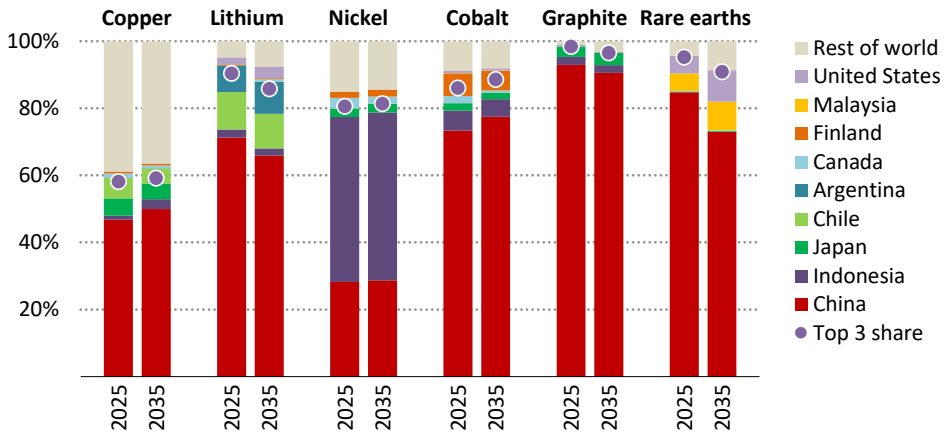
Figure 7.20 ▷ **Key suppliers of refined critical minerals based on operating, under-construction and high-probability projects, 2025 and 2035**



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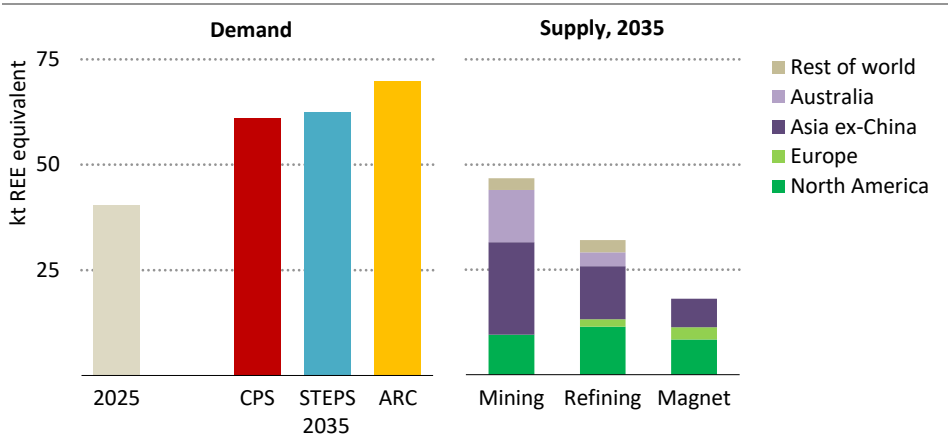
High concentration in refined critical mineral supply is set to persist through the next decade, despite modest diversification gains for lithium and rare earths

Notes: Figures for graphite are based on battery-grade graphite, including spherical graphite and synthetic graphite. Rare earths refer to magnet rare earth elements only. Shows production from existing and under-construction assets, and projects with a high chance of moving forward.

Figure 7.21 ▷ **Projected magnet rare earth demand by scenario and expected production outside the top producer, 2025 and 2035**



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Additional projects are needed across the rare earth value chain to reduce dependence on the dominant supplier, particularly in refining and downstream magnet production

Notes: REE = rare earth element. Supply estimates include production from existing and under-construction assets, and projects with a high chance of moving forward.

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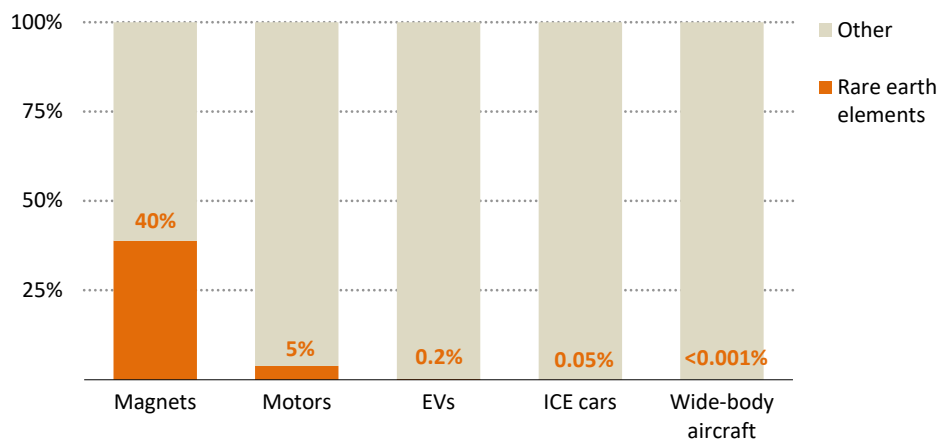
Overall, project pipelines reveal a structural imbalance in diversification efforts, with refining and downstream capacity lagging behind mining (Figure 7.21). These concerns extend beyond key energy minerals to strategic minor minerals, which often have smaller markets but even higher levels of supply concentration. With semiconductors, robotics and artificial intelligence likely to drive the next wave of innovation, securing supplies of gallium, germanium, indium, antimony and rare earths is becoming increasingly important.

Diversification requires investment to achieve more balance across value chains, supported by well-designed policy tools that reduce investment risks. Grants, equity participation, concessional loans and loan guarantees could lower upfront financing barriers for capital-intensive projects. Contracts for difference, price cap-and-floor mechanisms and offtake backstops could support operating expenditure and improve project viability by reducing price and volume risks. These could be complemented by demand-side measures such as diversified sourcing requirements and facilitated offtake agreements to provide predictable demand and improve project bankability.

Figure 7.22 ▷ Share of rare earth elements in the final price of magnets, motors, EVs, ICE cars and wide-body aircraft, 2025



Rare earth elements make up 40% of the value of permanent magnets but less than 1% of the value of electric and conventional cars

Notes: EV = electric vehicle; ICE = internal combustion engine. Other includes all other components, materials and margins that contribute to the final product price. Magnet refers to a rare earth element permanent magnet for a midsize battery electric vehicle (BEV); motor refers to a 100 kW EV motor; EV refers to an average BEV; ICE refers to an average internal combustion engine vehicle. Utilises the 2025 average material and product prices.

Source: IEA analysis based on Bloomberg (2026).

While diversified supply can involve higher costs, critical minerals generally account for a small share of final product prices. This suggests the additional cost of diversification could be absorbed with limited impact on consumers. For example, critical minerals account for

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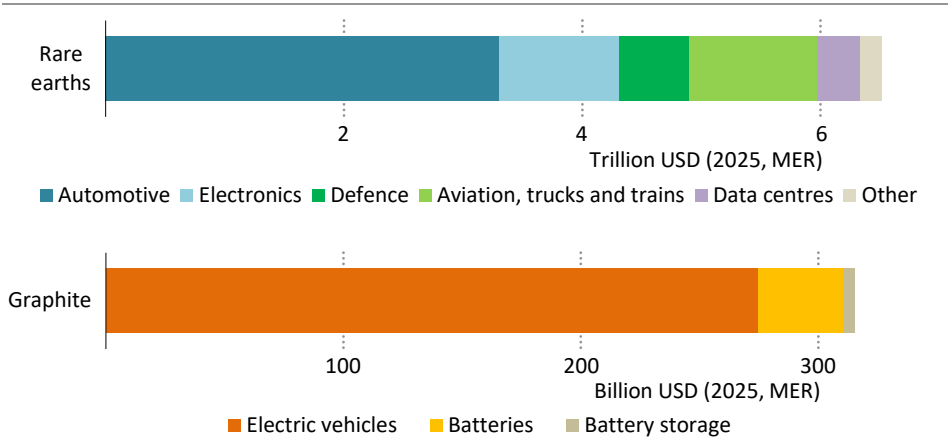
around one-quarter of battery cell costs but only about 3% of the price of an average electric vehicle, while rare earths represent around 40% of permanent magnet costs but less than 1% of the price of an average electric or conventional vehicle incorporating a permanent magnet (Figure 7.22). Diversification can entail additional costs beyond higher material prices, including supplier qualification, product testing and certification processes, and other switching costs associated with establishing new supply relationships, but these, too, are likely to have a limited effect on final product prices.

7.5.3 Flexibility

2025 marked the year when the economic risks of highly concentrated supply chains materialised at scale. In April 2025, the Chinese government introduced major export controls on seven heavy rare earth elements. These controls had a significant impact across downstream industries, with some vehicle manufacturers forced to reduce utilisation rates or temporarily halt operations. In October 2025, these controls were extended to cover internationally made products containing rare earths sourced from China or produced using Chinese technologies. Although these extended measures were suspended until November 2026, the vulnerabilities were clear, and they have not disappeared. The full implementation of the proposed extended measures could put at risk an estimated USD 6.5 trillion per year of downstream production outside China across the automotive, high-tech, defence and energy sectors (Figure 7.23).

Figure 7.23 ▷ Economic value of downstream sales at risk outside China from full export controls on rare earths and battery-grade graphite, 2025



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Rare earth export controls put USD 6.5 trillion of downstream production per year at risk, while graphite export controls put over USD 300 billion at risk

Notes: Economic value of downstream product sales at risk outside China from full implementation of the rare earth and graphite export controls. Other includes wind turbines, air conditioners and other industrial equipment. Electric vehicle production includes both battery electric vehicles and plug-in hybrid electric vehicles. Battery storage includes both utility scale and behind-the-meter storage systems. Batteries include batteries produced for both electric vehicles and storage applications.

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In October 2025, China also announced export controls on battery manufacturing equipment and technologies and on key battery supply chain components, including cathode materials, cathode precursors and graphite anode materials. If battery-grade graphite trade were fully disrupted, over USD 300 billion per year of downstream production outside China would be at risk. This underscores how small volumes of critical minerals underpin vast economic value.

Strategic stockpiling of critical minerals could provide an important buffer to safeguard countries from supply shocks and disruptions while they develop new, diversified sources of supply. For the 11 highest-risk materials, the net annual cost of stockpiling one year of imports from the dominant supplier is estimated at less than USD 900 million. Countries will need to assess their own import dependencies and supply risks alongside costs and to weigh the costs against the potentially major economic impacts of disruptions. Other emergency preparedness measures include unlocking spare production capacity, accelerating the commissioning of new projects, temporarily allocating available supply to strategic industries and promoting efficiency and substitution.

7.6 Resilience

The risk of supply disruptions cannot be eliminated entirely. Severe weather, other natural hazards, and malicious attacks, both physical and cyber, can all threaten the secure and reliable operation of energy systems. Energy system resilience focuses on the ability to anticipate, withstand, respond to and recover from such disruptions, and it is increasingly a priority for governments. This section presents new analysis of disruptions to energy infrastructure, looking at key vulnerabilities, emerging risks and possible policy responses to strengthen energy system resilience.

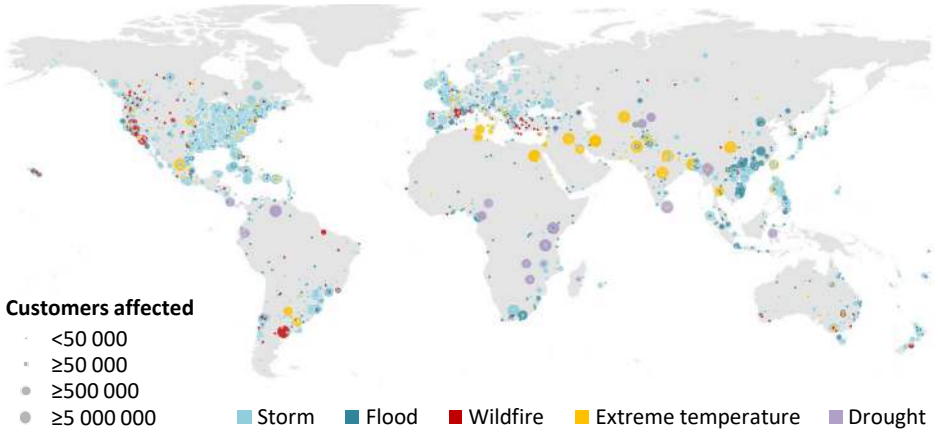
7.6.1 Disruptions from natural hazards

The electricity system is particularly vulnerable to natural hazards because of its reliance on extensive overhead infrastructure and its need to balance demand and supply at all times. The IEA has tracked around 3 000 reported power outages since 2022 linked to extreme weather and other natural hazards across more than 150 countries. Each year, these leave on average around 190 million customers temporarily without power, and some customers are affected on multiple occasions (Figure 7.24).

On average, more than 100 million of all tracked customer disruptions every year are rolling blackouts, which are often linked to heat and drought. Many of these events occur in rapidly developing regions with thin reserve margins, where rising peak demand and reduced output from generators may compound technical failures. Storms are the leading cause of unscheduled disruptions, accounting for around 85% of these events, but they are only responsible for just under one-third of overall disruptions. While storms, floods and wildfires (Box 7.3) often directly damage electricity infrastructure, heat and droughts typically build up strain on energy systems over time.

IEA. CC BY 4.0.

Figure 7.24 ▷ Power outages linked to natural hazards, 2022-September 2026



IEA. CC BY 4.0.

Since 2022, the IEA has tracked around 3 000 natural hazard-related outages, largely in severe-weather hotspots, though reporting skews towards advanced economies

Notes: Data until end of September 2026. Displays events leaving customers temporarily without power, including some affected on multiple occasions, as reported in the media, or estimated based on circumstantial information and Google Trends where not reported explicitly. Figures for floods include landslides. More detailed information on these disruptions is available on the IEA's Global Observatory for Energy Sector Resilience.

Source: IEA analysis based on GDELT (2026) and GDACS (2026).

Box 7.3 ▷ Electricity networks interfacing with wildfire risk

Electricity grids face a twofold risk from wildfires: they are vulnerable to disruption and damage, and they can also trigger fires themselves, notably via vegetation contact and arcing. Power assets at risk in connection with wildfires are often de-energised to reduce risks to the assets and to prevent them from contributing to fires. Over 180 power outages related to wildfires were recorded between 2022 and September 2026, including one caused by a fire in Argentina in 2023, which left 20 million people temporarily without power (Bidegaray, 2023).

More than one-fifth of all electricity grids globally pass through areas at risk of a wildfire occurring on average at least once every ten years. In South America, over 65% of above-ground assets face a ten-year risk of this kind; in North America, almost 550 000 km of lines pass through wildfire-prone areas (Figure 7.25). Grids near inhabited areas imply higher potential consequences in case of wildfires, albeit also with better access to firefighting capabilities. Over 20% of the global infrastructure with a ten-year fire risk also lies within 10 km of urban centres, and close to two-thirds within 50 km.

Where electricity has to be supplied across fire-prone areas, policy makers, regulators, utilities and industry need to work together to manage risks. Utilities are increasingly

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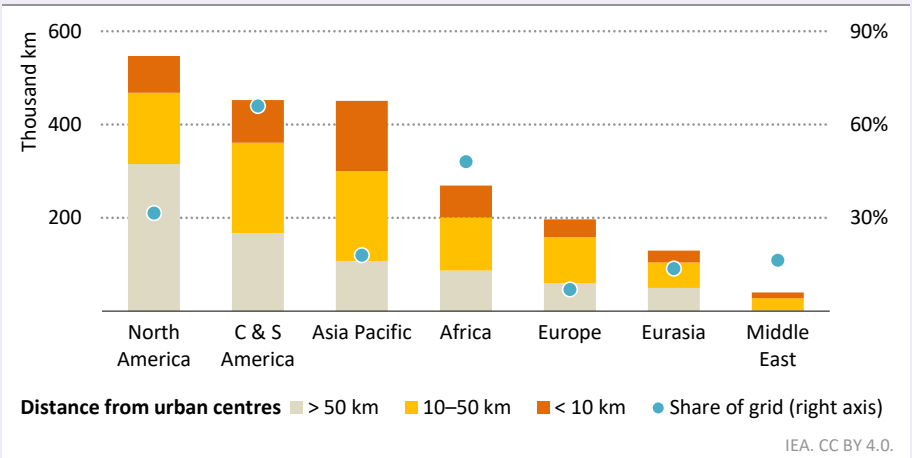
adopting construction and operating practices that take account of fire risks, including by using increased conductor clearances, covered conductors, encapsulated components, fire-resistant poles, and fast fault detection and protection systems. More costly measures such as network redundancy or undergrounding may be justified where potential losses are particularly high.

Policy makers can support measures designed to improve the resilience of energy assets in areas prone to wildfires, through clear standards, risk mapping, appropriate accountability frameworks and co-ordination across agencies and jurisdictions. How resilience measures are financed is becoming an increasingly important question as regulators seek to strengthen resilience while limiting the impact on consumers. Regulators are recognising resilience expenditure more explicitly and strengthening accountability for fires and wildfire-related disruptions.

Figure 7.25 ▷ Length of electricity grids in areas in which wildfires are expected on average at least every ten years, 2026



More than one-fifth of electricity grids around the world risk incurring downtime, damage or liability linked to wildfires

Notes: Electricity grid data as mapped until May 2026; subsea and underground assets excluded. Wildfire risk estimated as expected long-term average interval between fires, based on historical fire records, biomass density and the Fire Weather Index (FWI). High risk comprises the return period of 10 years or less, corresponding to a probability of at least 10%.

Sources: IEA analysis based on CEMS (2019); MODIS (2017); Santoro et al. (2021); OpenStreetMap (2026); JRC (2025).

The nature of these events varies widely from year to year. For example, tropical cyclones led to roughly five times more disruptions in 2024 than in other recent years (Figure 7.26). There were also fewer rolling blackouts in 2025 than in previous years, as some major developing countries that had faced recurring load shedding during the hottest weeks of the

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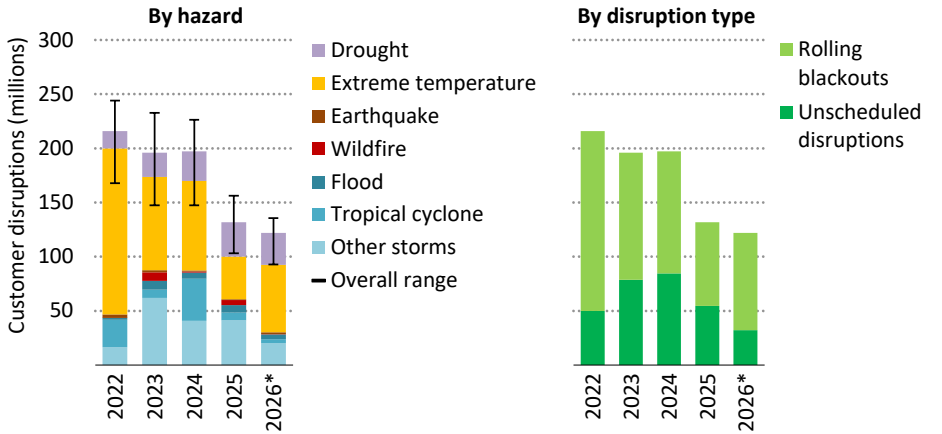
year had invested in increasing system margins and adopted additional operational measures to manage peak demand.

Figure 7.26 ▷ Power outages by natural hazard category and by disruption type, 2022-September 2026



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Storms account for around 85% of unscheduled disruptions linked to natural hazards, while heat and drought contribute to the majority of disruptions through rolling blackouts

Notes: 2026* = data until end of September 2026. Counts affected customers temporarily without power, including some affected on multiple occasions, as reported in the media, or estimated based on circumstantial information and Google Trends where not reported explicitly. Figures for floods include landslides. More detailed information on these disruptions is available on the IEA's Global Observatory for Energy Sector Resilience.

Source: IEA analysis based on GDELT (2026) and GDACS (2026).

While all parts of the energy system experience natural hazards (Figure 7.27), the extent of exposure differs between asset classes. An assessment of energy assets by the IEA finds that floods, storms and extreme heat pose the most widespread risks. Flood risk is particularly significant for assets located near shorelines, whether to facilitate fuel transport by ship or access cooling water. Nearly a quarter of refineries are located in floodplains, as are around one-sixth of seaports and power plants. Many energy assets are also located in coastal regions exposed to tropical cyclones. Others experience at least 40 days of extreme heat annually, and oil and gas infrastructure is particularly exposed.

Changing climate and weather patterns are expected to intensify hazards for many existing energy assets, with implications for infrastructure design and investment. Across all energy assets, the share exposed to at least 40 days of extreme heat annually is projected to rise by 70-230%, with tanker-handling seaports and refineries seeing the largest increases. Around 30% of power generation capacity and refineries located in floodplains are projected to face significant increases in maximum one-day precipitation levels, heightening the flood risk.

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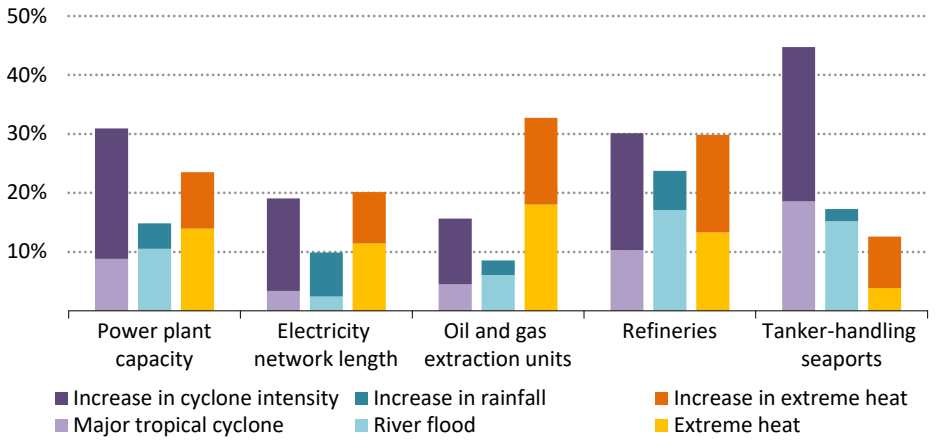
Meanwhile, cyclone-prone regions may experience more intense storms, exposing areas historically affected by Category 1-2 cyclones to stronger events.

Figure 7.27 ▷ Share of energy infrastructure and seaports exposed to extreme weather events, current and potential increase



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Energy assets face significant exposure to floods, cyclones and extreme heat, with climate change set to intensify these hazards for many regions

Notes: Exposure to tropical cyclones and river floods is assessed for 1-in-500-year events. Major tropical cyclones are defined as Category 3-5 storms on the Saffir-Simpson Hurricane Wind Scale, with sustained winds exceeding 177 km/h. Flood risk to power plants excludes hydropower. Heavy rainfall increase refers to a ≥ 10% rise in maximum one-day precipitation relative to pre-industrial levels. Extreme heat is defined as ≥ 40 days per year with maximum daily temperatures exceeding 35 °C (TX35). Increase in rainfall and extreme heat refer to projections for 2041-2060 and follow the IPCC SSP2-4.5 scenario. Seaports include ports averaging at least one tanker landing annually over 2019-2025.

Sources: IEA analysis based on GEM (2026); OpenStreetMap (2026); IMF PortWatch (2026); JRC (2024); Bloemendaal et al. (2023); Copernicus Climate Change Services (2025); IPCC (2021).

7.6.2 Disruptions from attacks

Energy infrastructure has become an increasingly prominent target in conflicts. Since 2022, energy infrastructure in Ukraine has been repeatedly targeted, with energy assets accounting for nearly one-quarter of civilian infrastructure targets. In the conflict in the Middle East, the figure is even higher; energy assets have been the target of more than 50% of attacks on civilian infrastructure (ACLED, 2026).

The impacts depend on the assets targeted. Fuel infrastructure, including refineries, LNG terminals and pipelines, represents concentrated, high-value targets whose disruption constrains fuel availability and export revenues, potentially for extended periods while repairs are undertaken. Electricity infrastructure presents a different vulnerability: because power systems are interconnected, attacks can rapidly disrupt essential services, local

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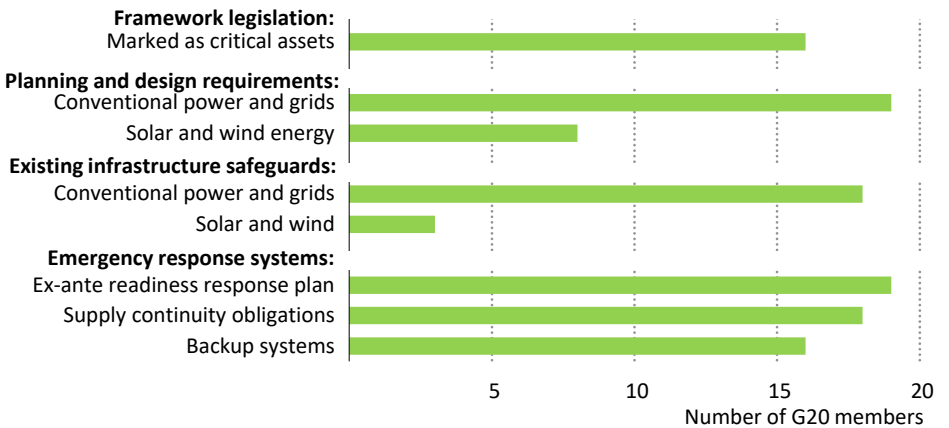
communities and economic activity. In Ukraine, intensified Russian strikes on electricity infrastructure in 2025 contributed to persistent shortages and frequent blackouts, which at times also affected district heat supply (IEA, 2026d). This was compounded by an exceptionally harsh winter and attacks targeted on gas infrastructure to disrupt winter heating and industrial activity.

The threat extends beyond conventional physical attacks. As energy systems become more digitalised and distributed, cyber operations and co-ordinated attacks using relatively accessible technologies, including drones, are expanding the range of potential threats. In 2025, there were more than 2 000 reported cyberattacks per week on energy utilities worldwide (Check Point, 2026). In addition, more than 7 000 incidents of terrorism and sabotage linked to energy facilities were recorded between 1970 and 2018 (Lee, 2022). Common targets are electricity networks, oil and gas facilities, and subsea cables.

7.6.3 Policy frameworks for energy system resilience

For the first time, the IEA has mapped key energy resilience policies across all G20 members, looking at four policy categories – detailed energy provisions within wider resilience framework legislation, resilience requirements for the planning and design of new infrastructure, resilience requirements for existing infrastructure, and emergency response provisions linked to energy (Figure 7.28).

Figure 7.28 ▷ Policy frameworks for energy resilience in G20 member countries, as of August 2026



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Resilience policy frameworks are common among G20 members for most conventional installations but have yet to be developed in most cases for solar and wind

Note: Conventional power and grids include nuclear, hydropower, coal, oil and gas power plants, and oil and gas transmission and distribution infrastructures.

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Nearly all G20 members designate the energy sector as critical infrastructure and have special provisions to ensure the continuity of energy services during crises. Nineteen G20 members have national-level mandatory emergency preparedness plans covering disruptions to key energy infrastructures, including specific protocols for hydro, nuclear, oil and gas emergency management. These plans typically include requirements for incident reporting, contingency planning and emergency response.

Specific resilience requirements on energy infrastructure exist for almost all G20 members. For new assets, 19 members have adopted resilience requirements that include drawing up resilience assessments and using design criteria intended to ensure that infrastructure can withstand extreme weather and potential attacks; some also use spatial planning rules to avoid high-risk areas. For existing assets, requirements most commonly focus on enhanced maintenance obligations, stronger physical security measures and the inclusion of energy-specific elements in cybersecurity strategies. Resilience policies and requirements are mainly aimed at traditional, centralised assets, particularly grids, oil and gas pipelines, power plants and nuclear facilities. For example, more than 80% of G20 nuclear capacity is covered by dedicated, stringent safeguards, compared with just 2% of solar and wind capacity.

Responsibility for energy system resilience is distributed across transmission and system operators, asset owners, private firms and disaster preparedness authorities. In many countries, transmission system operators are the key actors responsible for maintaining electricity system reliability and co-ordinating restoration and emergency operations. Elsewhere, regulators set recovery, availability and resilience standards for asset owners and critical infrastructure operators. Policy makers increasingly establish resilience standards and frameworks, leaving developers and operators to select cost-effective measures suited to specific assets and local hazards. These span system design, physical protection, operational practices and enhanced monitoring.

7.7 Energy access

A lack of access to energy is the most fundamental form of energy insecurity: without energy, households and communities cannot meet the basic needs that underpin health, education, economic growth and broader development goals. How countries gain access also carries important implications for energy security, and energy security considerations are becoming increasingly central to national access strategies.

7.7.1 Status of energy access

There are still large gaps in access to modern forms of energy today. Around 720 million people worldwide do not have access to electricity, about 90% of whom live in sub-Saharan Africa. The deficit in clean cooking is larger still: close to 2 billion people lack access to clean cooking solutions, around half of them in sub-Saharan Africa (Figure 7.29). Accelerating access is a major priority for many countries where there are still access gaps. In sub-Saharan

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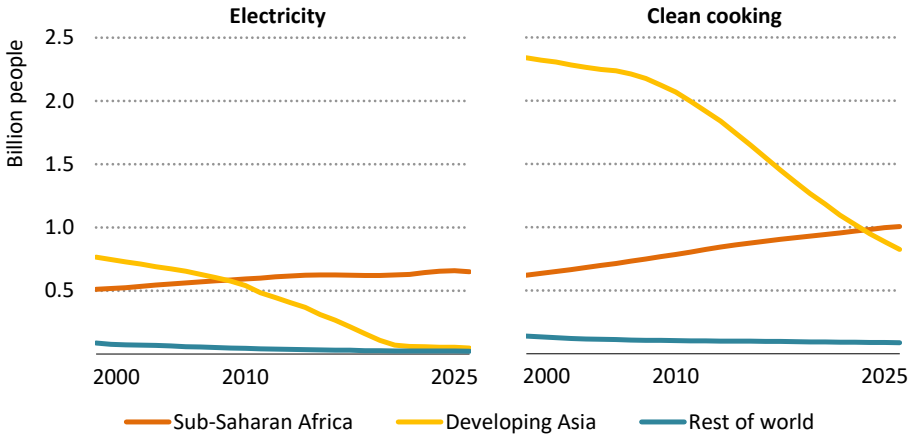
Africa, around 120 clean cooking policies or programmes have been announced since the 2024 Summit on Clean Cooking in Africa; around 90% of people without electricity live in countries with an access target, and 35 or more have adopted Mission 300 compacts.

Figure 7.29 ▷ Population without access to electricity and clean cooking by region, 2000-2025



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While many countries in Asia have advanced quickly in expanding energy access, similar gains have not been seen in some other regions, particularly sub-Saharan Africa

7.7.2 Clean cooking

Over the past decade, around three-quarters of people gaining access to clean cooking have done so through LPG, a cost-effective and storable fuel that does not need expansive distribution infrastructure (Figure 7.30). In the STEPS, around 640 million people gain access to clean cooking by 2035, but the number of people gaining access in sub-Saharan Africa does not keep pace with population growth, meaning that around 1.6 billion people globally still lack access by 2035. LPG remains the dominant fuel for new access. This reliance on a single, largely imported fuel concentrates risks. When supply is disrupted, as it has been in 2026, the impact on households is greater than it would be in a more diversified system.

In the ACCESS,[4] universal access is achieved through the least-cost combination of LPG (63%), electricity (18%), natural gas (6%), bioethanol (5%), biomass pellets (5%) and biogas (3%). LPG's lead reflects its cost-effectiveness and its potential to be scaled up rapidly. Although LPG is a fossil fuel, switching to it from the traditional use of biomass can reduce overall

[4] The ACCESS highlights that matching the best historical rates of progress seen to date in countries that share similar conditions (economic, demographic, etc.) could deliver universal access to electricity by 2035 and universal access to clean cooking by around 2040. See IEA (2025c) for further details.

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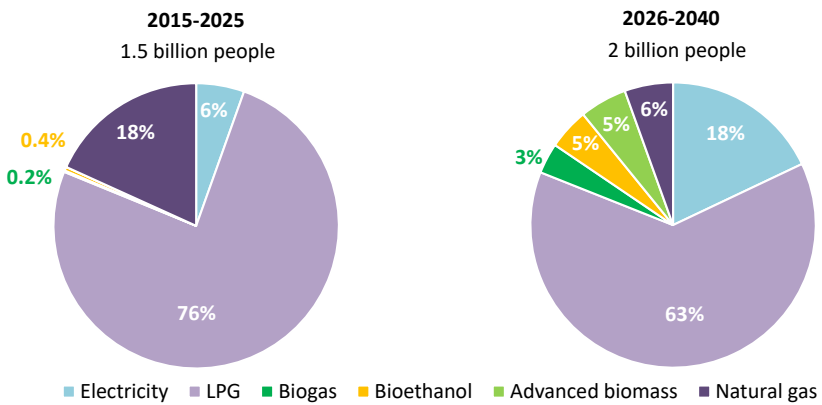
greenhouse gas emissions by cutting deforestation and emissions from the incomplete combustion of solid fuels. Other fuel options that draw on domestic and renewable resources also play a role where they can affordably reduce dependence on imported fuel. Achieving universal access depends on supporting conditions for the use of these fuels, including distribution networks, storage, financing and a reliable electricity supply for electric cooking.

Figure 7.30 ▷ Share of population gaining access to clean cooking solutions by fuel in the ACCESS, 2015-2040



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Most people that gain access to clean cooking do so through LPG, but there is an increasing push for electric cooking towards 2040 in the ACCESS

Note: ACCESS = Accelerating Clean Cooking and Electricity Services Scenario.

The 2026 energy crisis has exposed vulnerabilities in clean cooking fuel supply chains. Around 3.5 billion people worldwide rely primarily on LPG for cooking, and 30% of globally traded LPG cargoes transit the Strait of Hormuz. When flows through the Strait fell sharply in March 2026, the effects were felt most acutely in Asia. India was particularly exposed, with imports falling by more than half over the first two months of the conflict in the Middle East. Physical shortages were generally limited, but prices rose. Regulated markets absorbed much of the shock through higher fiscal costs, while informal markets saw larger increases in prices.

Nearly 35 countries – mostly emerging market and developing economies – with significant LPG demand have storage covering less than 15 days of domestic demand (Figure 7.31). In India, the buffer covers just over ten days. Recognising this vulnerability, several countries across Africa and developing Asia have begun expanding their domestic LPG reserves and implementing other diversification strategies in recent years, and many others have since announced similar plans. A wave of new import and storage terminals adding more than 20 million barrels of capacity is due to come online between 2026 and 2028 in emerging market and developing economies. These include sizeable facilities in India, Kenya and Tanzania that will deepen regional buffers. Some of the countries most dependent on

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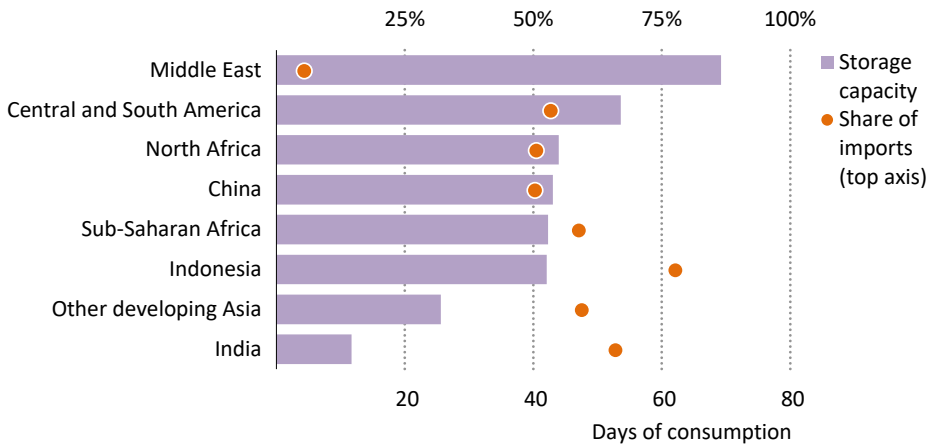
imported LPG, among them India and Indonesia, are also accelerating efforts to diversify their cooking energy mix. The resilience of clean cooking systems is being addressed through the IEA's Clean Cooking Security Programme.

Figure 7.31 ▷ LPG storage capacity and share of LPG demand met through imports in selected regions, 2025



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LPG storage capacity is limited in many countries, including some with high import dependence

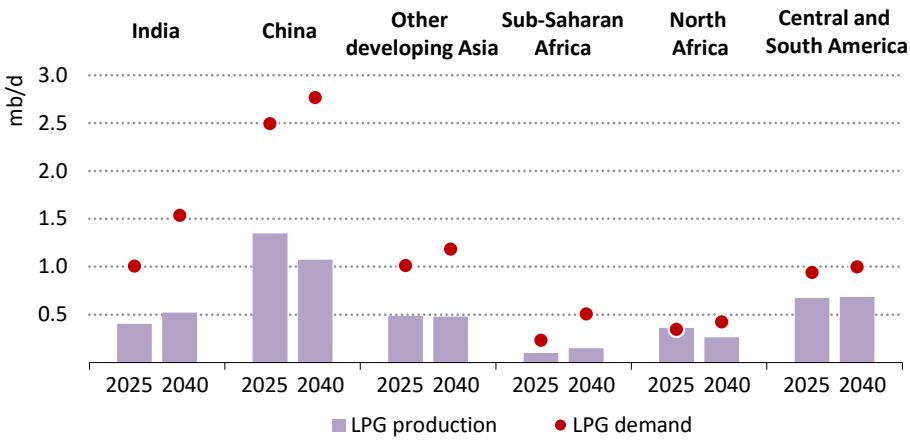
Source: IEA analysis based on Argus Media Group (2026). All rights reserved (full disclaimer on copyright page).

Higher domestic production of LPG can help to increase resilience, but only to a certain extent. In the STEPS, some key importing regions see growth in domestic LPG production to 2040 (Figure 7.32), but the opportunity is concentrated in a relatively small number of countries that combine sufficient feedstock, domestic demand and refining or processing infrastructure. The gap that must be met by imports or alternatives widens through 2040 as consumption outpaces local supply.

Diversification of clean cooking access pathways can also help strengthen resilience. Progress is already being made, drawing on resources that are largely domestic. The supporting supply chains are scaling up: manufacturing capacity for stoves, biomass pellets and bioethanol is expanding, and the push to universal access is itself a substantial source of industrial activity. However, clean cooking equipment manufacturing remains concentrated in a handful of producers, notably China and Türkiye. Policy is beginning to reflect this diversification, with several countries in developing Asia shifting the emphasis of their cooking strategies from expanding LPG towards electric cooking and natural gas in some contexts – a transition supported by comparatively high electricity access in the region and rising uptake of efficient induction appliances.

IEA. CC BY 4.0.

Figure 7.32 ▷ Domestic LPG production and demand by region in the STEPS, 2025 and 2040



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While some key importing regions and countries increase domestic LPG production, they see continued or widening dependence on imports

7.7.3 Electricity access

In the STEPS, around 300 million people gain access to electricity to 2035. Those gaining access do so largely through approaches already established: extending existing networks and building on programmes now under way.[5] However, around 530 million people in sub-Saharan Africa remain without access in 2035, most of them in rural areas, as population growth partially offsets progress in delivering electricity access.

In the ACCESS, the global access gap closes by around 2035, and electrification efforts lean increasingly on domestic resources – notably hydro and solar PV – to minimise reliance on imports (Figure 7.33). Grid extension remains the preferred solution to provide electricity access, delivering 45% of new connections where population density and proximity to existing networks allow, with mini-grids and stand-alone systems serving a further 30% and 25%, respectively.

Beyond connections, access also means having a dependable supply of electricity (Figure 7.34). Using survey data from Afrobarometer, the IEA estimates that around 360 million of the 900 million people with electricity access in Africa live in households reporting that grid power is available only half the time or less. Just 290 million report having electricity at all times, of whom 160 million live in North Africa (Afrobarometer, 2026). This

[5] For more details on electricity access, please see the definition in Annex C of this report or refer to the IEA's Guidebook for Improved Electricity Access Statistics (IEA, 2023b): https://www.iea.org/reports/guidebook-for-improved-electricity-access-statistics

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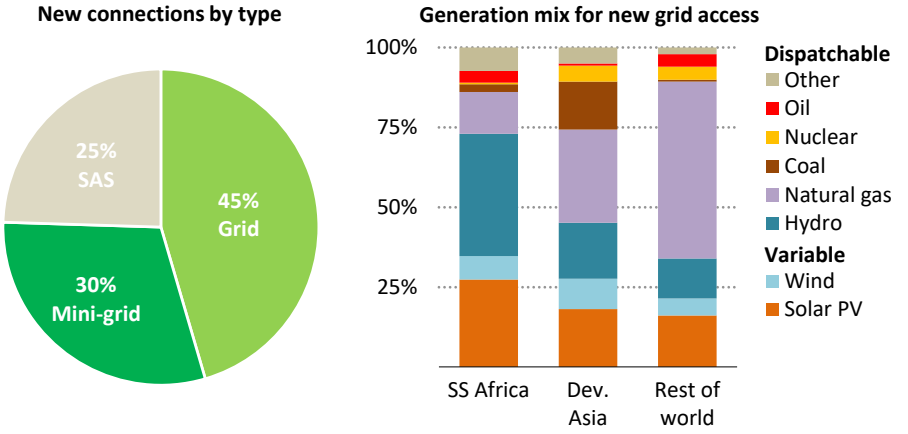
unreliability has far-reaching implications, constraining the uptake of household appliances, the adoption of freezers, fridges and electric cooking, and the use of electricity for productive activities, including by small enterprises operating from the home.

Figure 7.33 ▷ Share of people gaining access by connection type and generation mix in the ACCESS, 2026-2040



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In the ACCESS, 45% of people gaining access are connected via grids, while mini-grids connect 30% and stand-alone systems connect 25%

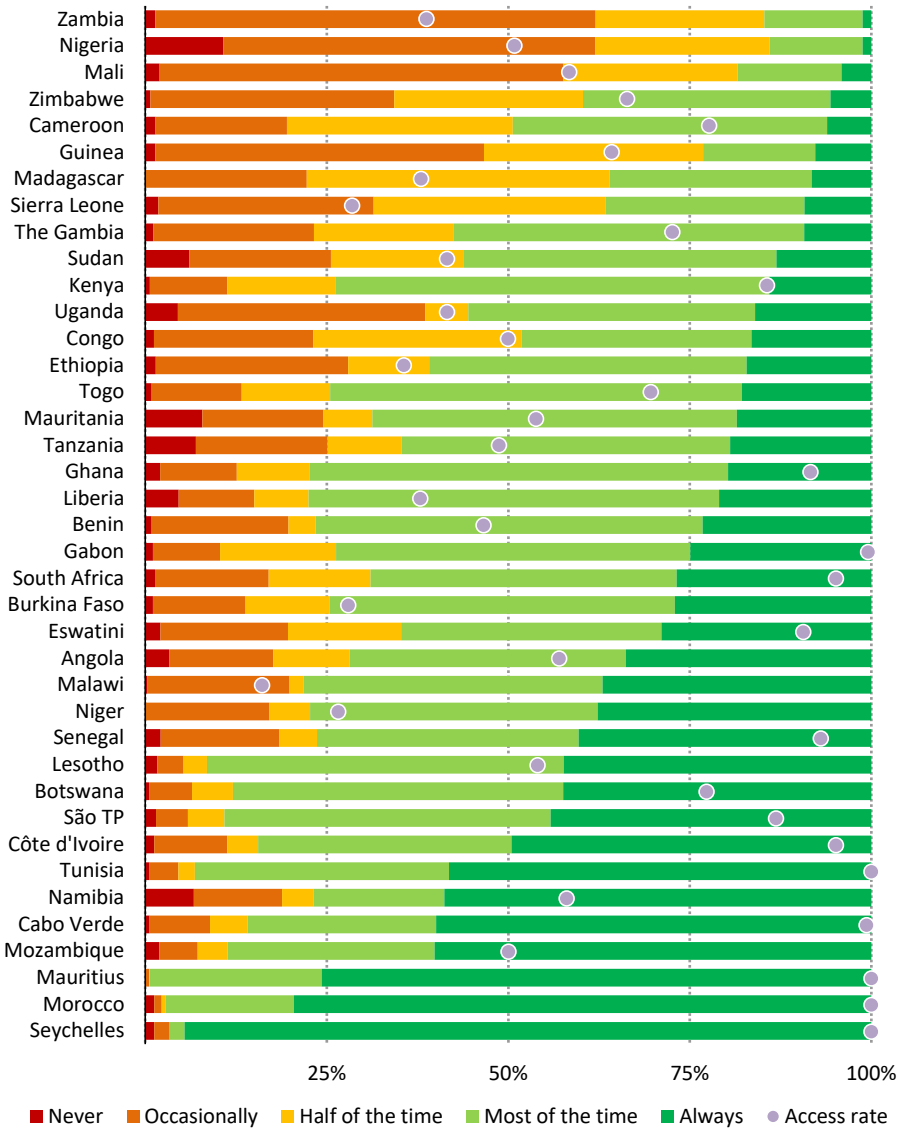
Notes: SAS = stand-alone system; SS Africa = sub-Saharan Africa; Dev. Asia = developing Asia. The generation mix presented here includes grid-connected generation, off-grid generation and stand-alone systems.

Distributed technologies – small-scale generation installed by customers to back up or replace grid supply – can complement an unreliable central grid, although they present their own challenges. Today, the dominant distributed technology in areas with unreliable central supply is diesel and petrol generator sets. The IEA estimates that distributed generator sets account for 125 GW of installed capacity in sub-Saharan Africa, compared with 205 GW of installed on-grid capacity from all sources. Consumption from distributed generator sets amounts to 290 thousand barrels per day, equivalent to almost 15% of the region's final consumption of oil products. Distributed generator sets provide access for customers that can afford them, but they are expensive and polluting, and they raise fuel imports in importing countries.

Solar PV, in some cases combined with batteries, is providing another pathway for distributed generation. As with distributed generator sets, it can provide access where the grid is absent and complement an unreliable grid for connected customers. It can also reduce dependence on imported fuels: its expansion rests instead on imports of solar modules and, in some cases, batteries, which have risen substantially over the past five years in emerging market and developing economies. In particular, China's solar PV exports to these economies have increased almost fivefold since 2021.

IEA. CC BY 4.0.

Figure 7.34 ▷ **Share of grid-connected population by reported frequency of availability of grid electricity in selected countries in Africa, 2025**



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In Mali, Nigeria and Zambia, grid-connected households report that electricity is unavailable more often than it is available

Notes: São TP = São Tomé and Príncipe; Congo = Republic of the Congo. Bars show shares of the grid-connected population reporting that electricity from the grid is available.

Source: IEA analysis based on Afrobarometer (2026).

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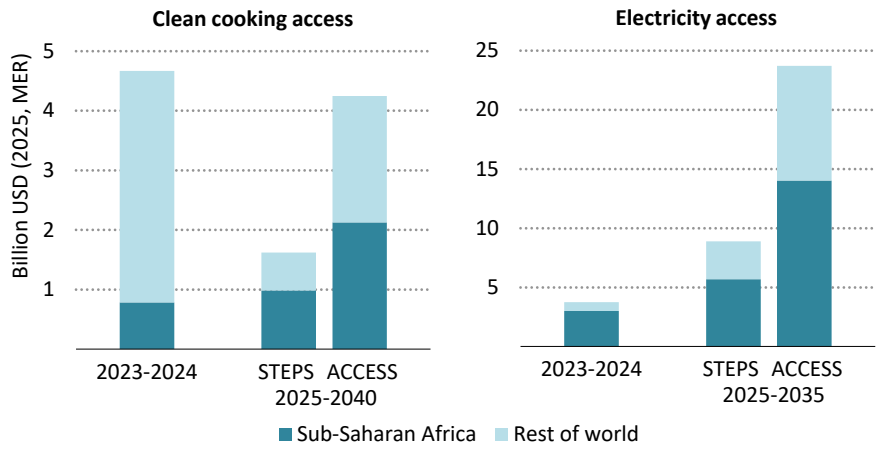
Solar PV systems also introduce new challenges for grid planning and integration. When distributed technologies are deployed to offset grid unreliability, they can reduce demand for grid electricity. This reduction in turn can weaken the ability of utilities to invest in grid modernisation and expansion. Mini-grids and stand-alone systems need to be planned together with grid extension so that investments do not strand one another. This calls for integrated planning and regulation, which can also take into account the potential for anchoring projects around productive uses to boost their commercial viability. Scalable, sustainable business models with clear rules are increasingly being used to promote an integrated approach, raise solar home system quality standards and set affordable tariffs that recover efficient costs, with targeted subsidies covering any gap.

7.7.4 Investment needs for access

The ACCESS calls for investments of around USD 4 billion for clean cooking and around USD 24 billion for electricity access each year until access is achieved. This exceeds what today's policies deliver to 2035 and requires a substantial increase in electricity access investment from recent levels and a shift in clean cooking investment towards sub-Saharan Africa (Figure 7.35).

Figure 7.35 ▷ Average annual clean cooking and electricity access investment in the STEPS and ACCESS, 2023-2040



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Universal access to clean cooking can be reached with investments of around USD 4 billion per year, while electricity access requires annual investments of around USD 24 billion

By some margin, electricity accounts for the larger share of the investment needed, reflecting the networks, generation and connection infrastructure required to reach the 720 million people still without supply, most of whom live in rural areas in sub-Saharan Africa. Average annual investment in electricity access ran at under USD 4 billion between 2023 and 2024; in

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the STEPS, it rises to around USD 9 billion a year to 2035, but this is still well short of the level needed to close the gap. Attracting the necessary investment depends on sound regulation and business models, reforms to multilateral and bilateral lending, and an expansion of concessional finance, grants and risk mitigation instruments to overcome high financing costs and perceived risks.

Clean cooking requires far smaller sums to deliver universal access – under a fifth of the total for electricity – but has historically struggled to attract them in some regions. Annual investment averaged USD 4.7 billion between 2023 and 2024, but this decreases in the STEPS to USD 1.6 billion a year to 2040 as many countries in developing Asia approach universal access. However, progress remains relatively slow in Africa. The ACCESS requires roughly three times the level of investment seen in the STEPS to fund household equipment such as stoves, cylinders and canisters, together with the enabling infrastructure of distribution networks, storage terminals and grid upgrades. Recent momentum is encouraging: the first Summit on Clean Cooking in Africa, held in May 2024, mobilised USD 2.2 billion in commitments from governments and industry, of which USD 740 million has been disbursed to date, and a further USD 900 million in new commitments has been announced in 2026.

7.8 Affordability

Affordability is a central concern of policy makers, producers and consumers. This section examines the factors shaping retail electricity and fuel prices, analyses how prices and energy consumption determine household bills and looks at how the overall costs of the energy system evolve across scenarios.

7.8.1 Electricity and fuel prices

The electricity tariffs that households pay reflect different combinations of energy, network and policy costs across countries, and they are shaped by country-specific pricing policies, market designs, taxes, subsidies and cost allocation practices (Figure 7.36).[6] Energy supply costs are a key driver, with network costs becoming an increasingly important component as electricity systems expand and modernise. Fiscal policies also play an important role. Some countries provide substantial subsidies for household electricity, resulting in tariffs that can fall below the cost of supply, while others impose taxes and levies on electricity consumption. As a result, household electricity prices vary widely between countries and do not necessarily mirror the underlying cost of the electricity system.

[6] Comparing household electricity prices across regions is challenging due to large differences between market and purchasing power parity exchange rates. Affordability for consumers is ultimately determined by their purchasing power, and comparisons of household electricity prices should be made using purchasing power parities. On this metric, for example, households in India pay relatively high electricity prices despite tariffs that are on average below the cost of supply. The comparisons use national or regional averages and therefore do not capture all subnational or household-level variation.

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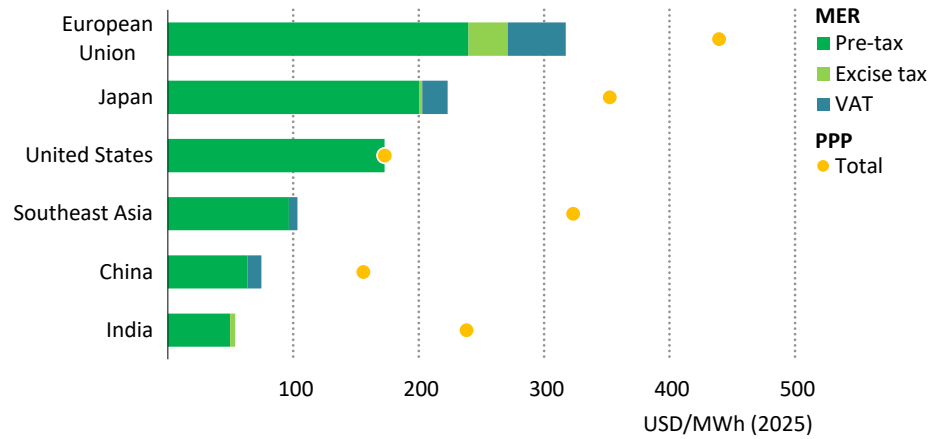
Figure 7.36 ▷ **Residential electricity prices by component in selected regions, 2025**



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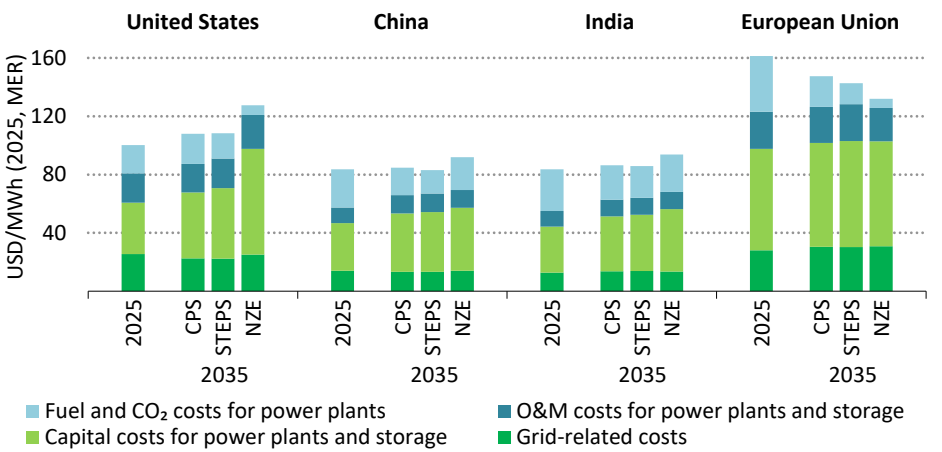
Household electricity prices reflect both energy system costs and policy choices on taxes, levies and subsidies

Note: MWh = megawatt-hour; VAT = value-added tax.

Figure 7.37 ▷ **Electricity system costs by component in selected regions by scenario, 2025 and 2035**



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Lower fuel expenditures are increasingly offset by higher spending on infrastructure, including grids, power plants and storage, reshaping the makeup of electricity system costs

Note: CO_2 = carbon dioxide; O&M = operating and maintenance.

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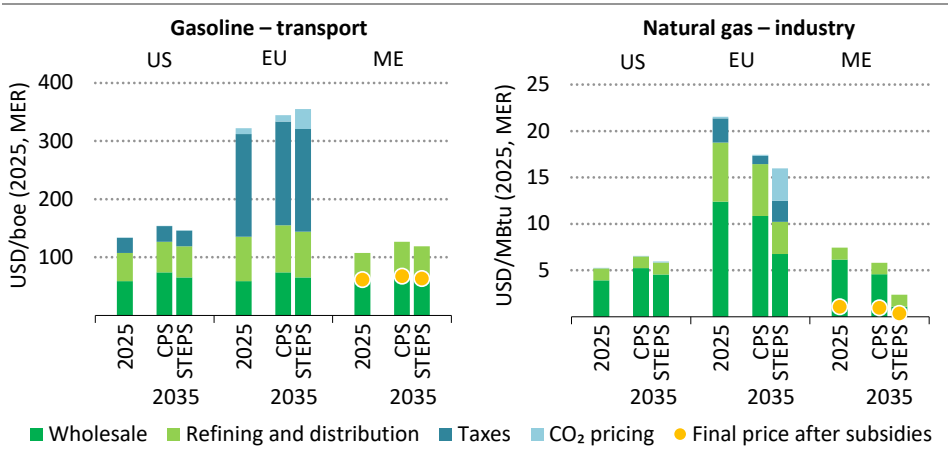
Over time, the composition of electricity costs shifts across most regions in our scenarios, with lower fuel and operating costs increasingly offset by higher capital recovery costs for networks and power plants (Figure 7.37). The growing role of long-lived capital investment helps to make electricity system costs relatively predictable. A large share of system costs (typically more than 60%) reflects the depreciation of long-term investments in power plants and networks. This cost structure introduces a significant degree of inertia because these investments are recovered over extended periods. At the same time, the declining share of fuel costs in most regions reduces exposure to volatile international fuel prices. Electricity systems therefore become more capital intensive but less fuel intensive, with greater stability in their underlying costs.

Changes in electricity system costs do not translate one-for-one into household prices. Assuming that current tax rates and levies stay as they are, except where governments have policies in place that will alter them, household electricity prices in China and India increase by 15-20% in the CPS and STEPS to 2035, with only a 5% increase on average in the United States. In the NZE Scenario, the more rapid power sector transformation means that prices face greater but temporary upward pressure in all three countries. In the European Union, by contrast, prices decline in all scenarios, most of all in the NZE Scenario.

Figure 7.38 ▷ Fuel prices by selected region and scenario, 2025 and 2035



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End-user taxes and subsidies are key drivers of divergences in fuel prices across regions; in the European Union, falling wholesale gas prices reduce end-user prices by 2035

Note: boe = barrel of oil equivalent; MBtu = million British thermal units; ME = Middle East.

As with electricity, end-user prices for fuels such as gasoline and natural gas are shaped by wholesale prices, infrastructure and distribution costs, and taxes and subsidies (Figure 7.38). As a result, differences in wholesale prices between scenarios are often muted at the consumer level. In general, oil prices are moderately higher in the CPS in 2035 than in 2025,

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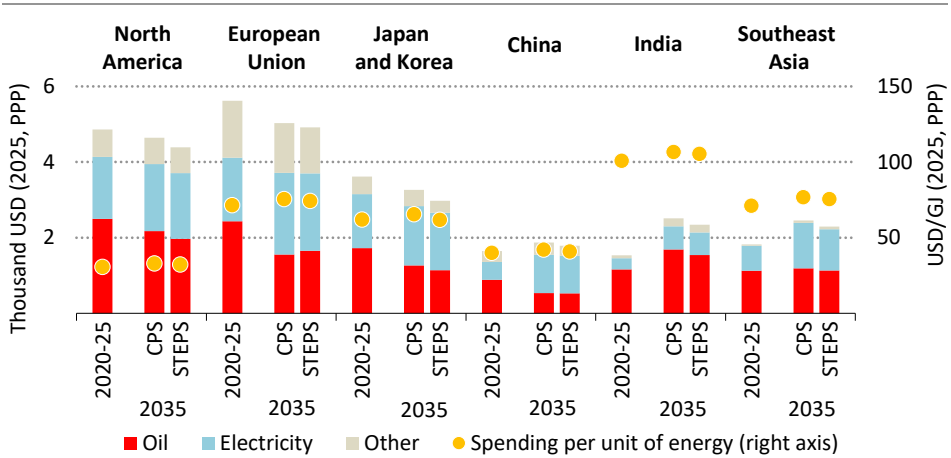
leading to higher end-user prices for fuels such as gasoline. For natural gas, however, importing regions such as the European Union benefit from lower wholesale gas prices in all scenarios as more LNG capacity comes online, resulting in a substantial reduction in end-user prices by 2035. In the Middle East, substantial subsidies continue to shape end-user prices, leaving them well below those in importing regions and lower than in the United States.

7.8.2 Household energy bills

Household energy bills are determined by a range of factors, including wholesale energy prices, network costs, taxes and subsidies, and the energy efficiency of equipment. Total bills are the product of prices and the volumes of energy consumed. Household bills are therefore also influenced by income levels, as households in lower-income countries tend to consume less energy. Relative to their purchasing power, bills per unit of consumption are high for consumers in India and Southeast Asia, despite end-user subsidies in some countries (Figure 7.39). Around 50% of an average household energy bill today reflects spending on oil products such as gasoline and diesel for personal transportation, and around 30% reflects the use of electricity for purposes such as heating, cooking and running appliances.

Figure 7.39 ▷ Total average annual household energy bills by energy source in selected regions by scenario, 2020-2025 and 2035



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Electricity accounts for a growing share of household energy bills across most regions

Note: Other includes natural gas, modern bioenergy, district heat, coal, hydrogen and hydrogen-based fuels.

The 2022 energy crisis pushed up both energy prices and household energy bills in recent years. Across scenarios, advanced economies generally see bills come down from their current high levels by 2035. The decline is particularly noticeable in the European Union, which was most affected by the 2022 energy crisis. Spending on oil products declines in advanced economies in all our scenarios as passenger transport becomes more electrified.

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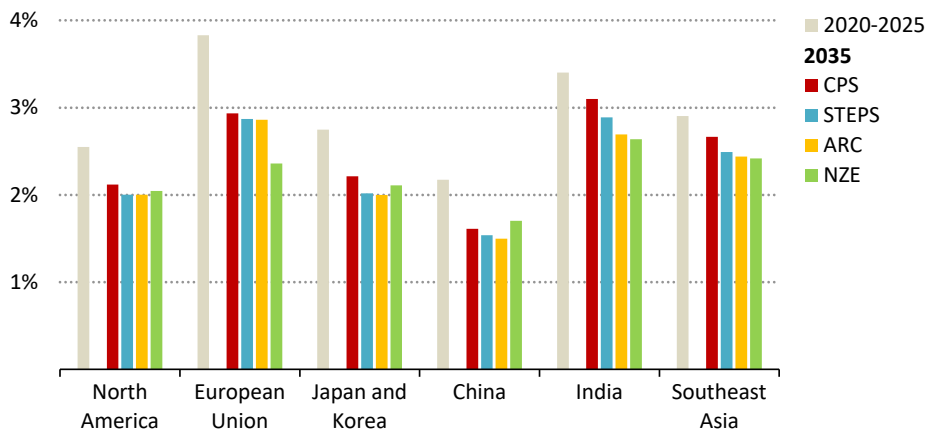
Bills in advanced economies are somewhat higher in the CPS than in the STEPS because energy consumption per household and international fuel prices are higher in the CPS. In the NZE Scenario, the cost per unit of energy rises, but this is often more than offset by energy demand reduction, enabled by energy efficiency, electrification and behavioural changes.

Absolute energy bills per household are lower in emerging market and developing economies than in advanced economies. However, this gap starts to close as incomes rise, and household bills in emerging market and developing economies increase in absolute terms across scenarios to 2035. China sees the smallest increase, in large part because of its rapid electrification over the next decade. Half the money spent on energy bills by households in China today goes on oil products; by 2035, the majority is spent instead on electricity in all scenarios. In India, households spend 50% more on energy by 2035 in the STEPS, but this is mostly due to rising energy consumption.

Normalising household bills by GDP helps to show how affordability pressures change over time across scenarios (Figure 7.40). In the European Union, total household spending on energy from 2020 to 2025 averaged nearly 4% of GDP, reflecting the surge in prices in 2022. This share drops substantially in all scenarios by 2035 as efficiency improves and prices normalise. Similar trends are seen in Japan and Korea. In India and Southeast Asia, incomes rise faster than bills, reducing household spending on energy as a share of GDP by 2035.

Figure 7.40 ▷ Household energy bills as a share of GDP by region and scenario, 2020-2025 and 2035



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Energy spending as a share of GDP drops substantially in most regions, with the strongest declines seen in the ARC or the NZE Scenario

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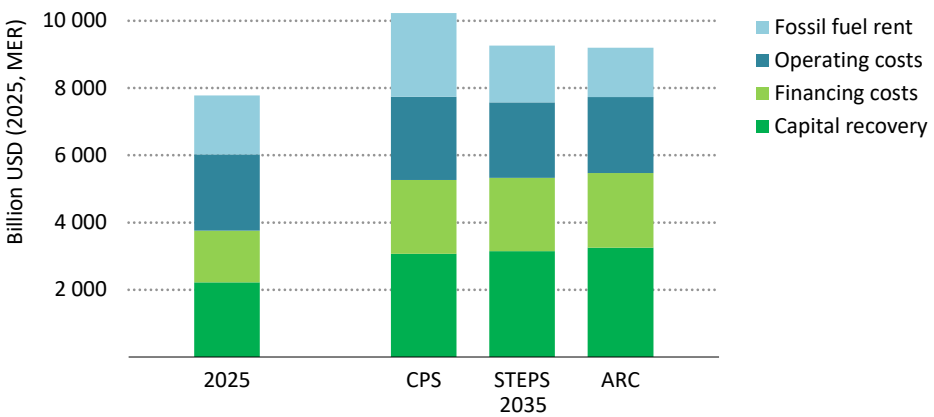
7.8.3 Total energy system costs

Delivering energy services requires investment across the energy system, with capital expenditure to build energy infrastructure – including oil and gas fields, power plants, electricity grids and LNG terminals – often recovered gradually through payments by consumers. Investments by households in technologies such as electric vehicles (EVs), heat pumps and building retrofits are also often paid for or financed over several years. These investment costs make up a large share of the total economic cost of delivering energy services, and they can be split into capital recovery and financing costs. Financing costs vary considerably depending on factors such as the perceived risk of the project, the country or region of investment, prevailing market interest rates, the creditworthiness of the borrower, and the specific regulatory or financial framework in place.

Operating costs and fossil fuel rents also need to be taken into account. Operating costs comprise the expenditure required to maintain energy assets and ensure the continued production, transport and storage of energy. Fossil fuel rents – an additional cost borne by energy consumers – are defined as revenues from fossil fuel sales minus the full costs of production, including financing costs. These rents accrue primarily to governments through taxes, royalties and income from national oil and gas or mining companies. They are distinct from the returns earned by renewable energy developers and utilities, which are already captured within financing costs.

Figure 7.41 ▷ Total energy system costs by component and scenario, 2025 and 2035



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The total costs of delivering energy to consumers globally grow more in the CPS than in the STEPS, mainly because of higher fossil fuel rents

Note: Excludes taxes and subsidies.

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Taking these components together, the total cost of operating today's global energy system is around USD 8 trillion per year (Figure 7.41). This figure excludes the additional taxes, levies or applicable environmental surcharges such as carbon dioxide (CO_2) prices that are imposed by governments. The total cost increases in both the CPS and STEPS as energy services expand to meet the needs of a growing global economy and population, but by 2035, it is almost 10% lower in the STEPS than in the CPS. The STEPS sees a higher level of electrification and greater investment in capital-intensive technologies, including end-use equipment such as EVs and heat pumps. This investment results in slightly higher capital recovery costs in 2035 than in the CPS. However, these are more than offset by higher operating costs in the CPS, which reflect higher fossil fuel prices, and by larger fossil fuel rents, which reflect both stronger demand for fossil fuels and higher fuel prices. Fossil fuel rents net of financing costs amount to USD 1.7 trillion in the STEPS in 2035, compared with USD 2.5 trillion in the CPS.

7.9 Synergies and trade-offs

Many of the actions that strengthen one dimension of energy security will reinforce others or support other policy objectives, such as efforts to reduce emissions and improve affordability. But not all objectives pull in the same direction, and it is where they conflict that choices often become most difficult. Drawing on the analysis above, this section looks at a selection of synergies and trade-offs between different types of energy security and the implications for other policy objectives.

Measures that strengthen several dimensions of security

Efficiency and electrification lower demand for oil and gas and can reduce exposure to volatile fuel markets. For importers, they also redirect expenditure from imported fuels towards largely domestic investment, which can support domestic employment and economic output. Similar synergies arise from efforts to expand domestic renewables and low-emissions fuels, which can also reduce import dependence, improve resilience to international price shocks and create options for meeting energy access needs.

Risk shifts: how reducing one security vulnerability can increase another

Electrification can reduce fuel security risks but increase exposure to concentrated critical mineral supply chains. The risks differ in timing and impact: fuel disruptions are felt immediately by consumers, whereas mineral shortages mainly constrain new clean energy infrastructure and mineral-dependent industries. However, electrification could shift part of the security challenge from fuel to mineral markets unless diversification, recycling, substitution and strategic stockpiling keep pace with deployment.

Electrification and the deployment of variable renewables can reduce fossil fuel imports but risk undermining system adequacy and flexibility unless carefully sequenced with the expansion of supporting infrastructure. Fossil fuel power plants are a major source of short-term and seasonal flexibility in many countries, and reducing capacities before sufficient alternatives are in place could weaken electricity security. Several countries and regions are

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facing delays in building new power generation capacity and supporting infrastructure. Key components for grids and power system flexibility options also face supply chain constraints and, in some regions, difficulties in attracting investment.

Energy access strategies can also create trade-offs with fuel security. LPG has played a major role in expanding clean cooking access because it is familiar, scalable and often lower cost than other clean cooking options. But greater reliance on LPG can increase exposure to imported fuels, international price volatility, limited storage and maritime chokepoints. These risks are particularly acute where distribution systems depend on a small number of import terminals and suppliers.

Synergies and trade-offs between security and emissions reductions

In some net-importing countries and regions, the most effective way to improve fuel security is to boost investment in clean energy technologies. Investments of this kind can also accelerate emissions reductions. In other net-importing countries and regions, however, greater weight may be given to improving fuel security by increasing domestic fossil fuel production and consumption, despite the consequences for emissions.

The ARC sees a temperature rise of 2.4 °C by 2100, only marginally less than the 2.5 °C rise in the STEPS; the CPS sees a temperature rise of 2.9 °C. This warming will have consequences for people and the energy sector through the physical impacts of climate change. For example, around 45% of customer power disruptions from 2022 to September 2026 were linked to episodes of extreme heat. Investments in adaptation and in improving climate resilience will be necessary. The NZE Scenario[7] – in which the temperature rise peaks at just below 1.7 °C and falls below 1.5 °C by 2100 – has significantly lower adaptation needs. At higher temperatures, it would be extremely challenging to mitigate all new climate risks. Higher temperatures also increase the risk of triggering long-lasting or irreversible climate tipping points.

The ARC suggests that boosting clean energy deployment is in general much more effective than new fossil fuel developments in reducing oil and gas import dependence. Net oil and gas trade globally is 5 mb/d and 325 bcm lower in 2035 in the ARC than in the STEPS: more than 75% of the difference is due to the greater deployment of efficiency measures, end-use electrification and domestic renewables, and most of the remainder is associated with increased domestic fossil fuel production.

Synergies and trade-offs between security and affordability

Measures to improve energy security are crucial, but their costs need to be carefully weighed. To take one example, spending more on resilience and preparedness raises the cost of energy in normal times in exchange for lower exposure to price spikes and disruptions in a crisis. The benefits of investing in energy security may therefore never occur, or they may only materialise during crises, which are infrequent and unpredictable.

[7] A detailed discussion on the implications of the NZE Scenario for energy security is provided in Chapter 6.

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A balance also needs to be struck when expanding domestic sources of energy. Such expansion is often capital intensive and creates a risk of overcapacity or redundancy. For example, importing crude oil and refining it domestically preserves the ability to adjust the product slate during a disruption, but it could require maintaining capacity that may not be commercially viable in normal times.

Importers also face a choice between long-term contracts and spot procurement for fossil fuel imports. Spot markets allow importers to adapt quickly to changes in demand and will often provide cheaper energy outside crises, but long-term contracts provide more price and volume security.

The tension between higher domestic autonomy in energy and reliance on trade raises another set of issues. Trade in energy offers many benefits: it improves efficiency, provides flexibility and can plug gaps in supply that no single country can meet by itself. But trust in the trade of energy commodities and technologies has been undermined by actions including export bans. Vulnerabilities associated with high dependence on a limited number of suppliers and chokepoints have been exposed by recent energy crises. Industrial subsidies and state-owned enterprises have also raised questions around level playing fields in sectors like critical minerals.

Careful consideration also needs to be given to how energy security measures should be funded. Investments in energy security will not always generate sufficient returns for private investors, and the security benefits they generate are widely shared. Deepening the discussion about how responsibilities, risks and rewards are shared between public and private finance, and the instruments that can be used, is an important part of translating the security priorities identified in this chapter into actual investment.

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Regional insights

Diverse priorities, diverse pathways

SUMMARY

- This chapter explores energy sector trends and priorities in countries and regions that cumulatively account for about 90% of the world's population, gross domestic product (GDP) and energy demand. Of the ten regions considered, five are net energy exporters and five are net energy importers. Their levels of GDP and energy use vary widely: for example, car ownership levels in advanced economies are 6 to 9 times higher than in Southeast Asia and 15 to 20 times higher than in Africa or India.
- In a year when the impact of the energy crisis was felt across much of the world, countries responded to the crisis in different ways depending on their circumstances and priorities. For fuel importers, responses have included a short-term focus on mitigating the impact of the crisis on energy affordability, together with the development of longer-term policies designed to improve the resilience of supply chains, expand deployment of domestically available resources, notably renewables, and accelerate electrification. Developing countries in Africa and other regions face the added challenge of pursuing universal access to clean cooking and electricity.
- While the electrification of end-uses has grown globally, this growth has been uneven. Japan and Korea have long maintained high rates of electrification, but China is now closing the gap, and this indicator is rising rapidly in Southeast Asia. In the European Union, growth in the electrification of end-uses has been slower, despite heavy reliance on imported fuels, but domestic resources, including renewables and nuclear, meet 80% of electricity demand, which is a higher proportion than in most other regions. The European Commission has proposed an EU-wide target to reach a 46% electrification rate by 2040, partly with a view to reducing import dependence on fossil fuels.
- The link between economic growth and emissions is weakening. Over much of the past decade, advanced economies and Latin America and the Caribbean (LAC) have grown their GDP while reducing their emissions. In other parts of the world, including Africa, China and India, the rise in their GDP has outstripped the rise in their emissions. These developments reflect efficiency improvements, rising shares of low-emissions sources of energy and structural economic changes.
- This chapter includes a deep dive into a pertinent topic for each region. For Africa, China, Japan and Korea, and the United States, we explore themes relating to electricity generation and security. For the European Union and Southeast Asia, we look at pathways to higher end-use electrification. For Eurasia and the Middle East, we explore developments in energy supply. For LAC, we take a closer look at the region's position as a key supplier of critical minerals. For India, we look at the development of its oil refining sector.

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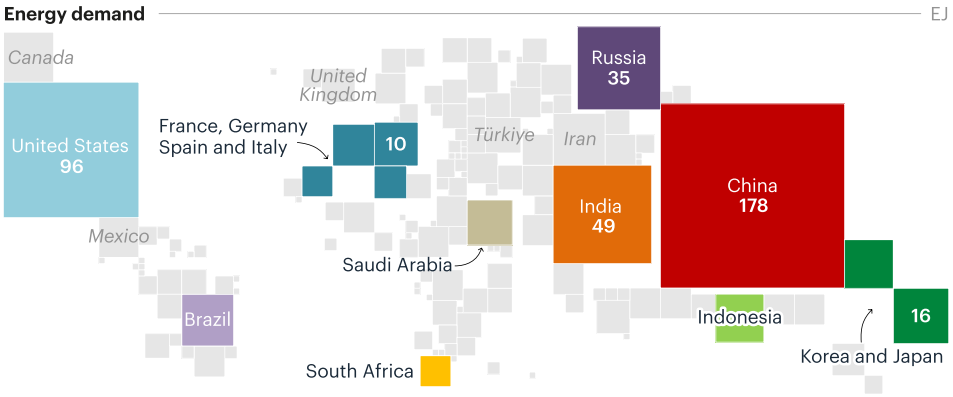
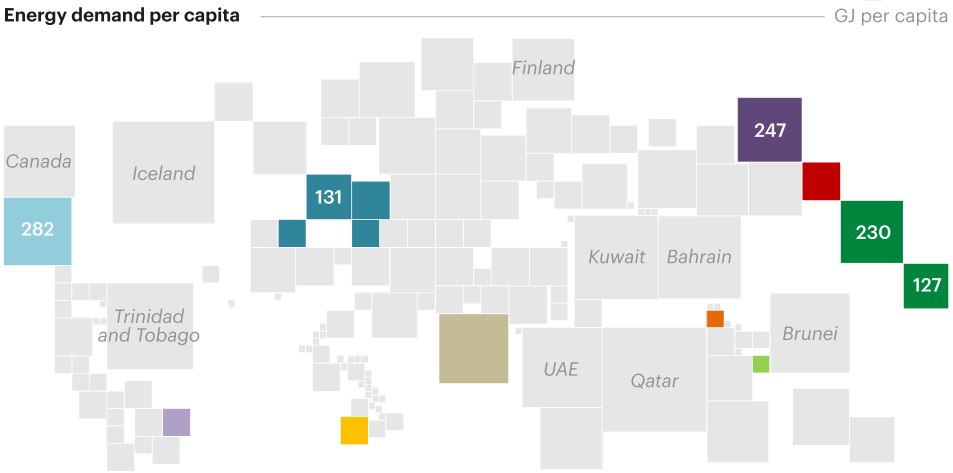
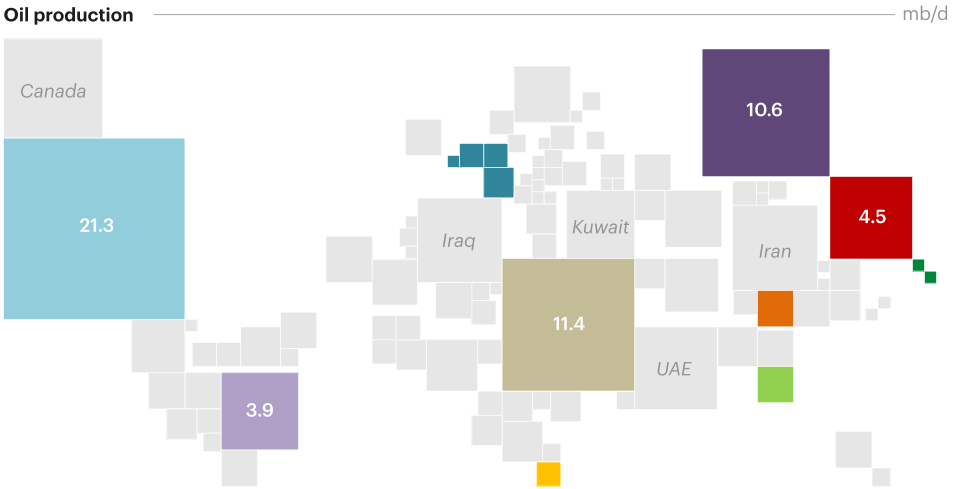
A diverse global energy landscape

Countries face very different energy challenges, shaped by their level of development, economic structure, resource endowments, ambitions and patterns of energy demand and trade. This infographic explores three indicators that illustrate this diversity in 2025.







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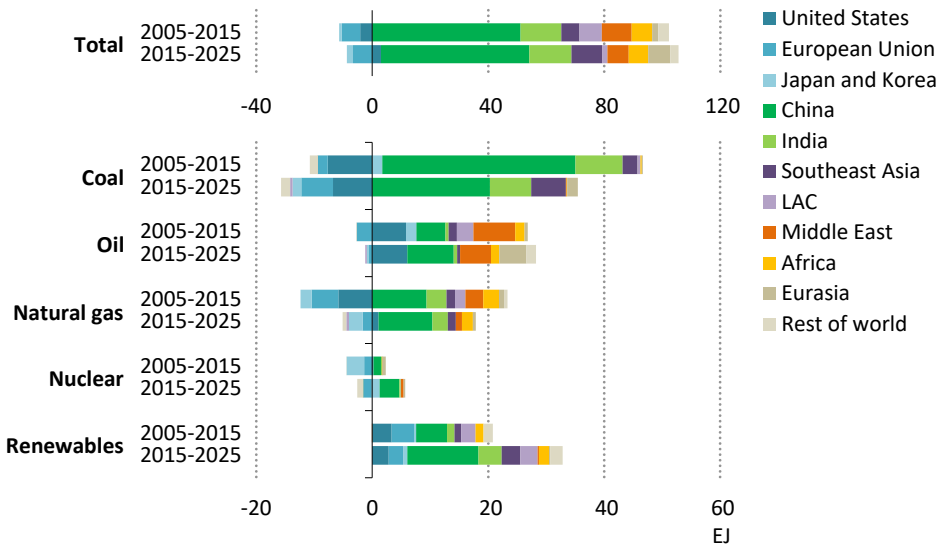
8.1 Introduction

This chapter explores energy sector trends and pathways for countries and regions that together account for around 90% of the world's population, gross domestic product (GDP) and energy demand. Recent trends point to growing regional diversity in both the drivers of energy demand and the fuels used, with important implications for energy security and trade.

Over the past two decades, 80% of the global energy demand growth has been driven by China, India and Southeast Asia. These regions account for around one-third of global GDP and are home to four in ten people globally. Energy demand has also been growing in Africa, although from a low base. In many advanced economies, energy demand remained broadly constant or declined. The United States was an exception, with energy demand growing by 3% between 2015 and 2025, reversing the 4% decline in the decade prior to that (Figure 8.1).

Figure 8.1 ▷ Change in energy demand by fuel and region, 2005-2025



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80% of the global energy demand growth has been driven by China, India and Southeast Asia, and renewables are playing an increasingly important role in meeting it

Note: EJ = exajoule; LAC = Latin America and the Caribbean.

Coal remained a major driver of energy demand growth over the past decade, but its contribution was much smaller than between 2005 and 2015. China has been responsible for a larger share of growth in demand for coal than any other country, but its demand growth in 2015-2025 was around 40% lower than in the earlier decade. Regional demand for coal in 2015-2025 grew fastest in Southeast Asia. Natural gas played a growing role in meeting global

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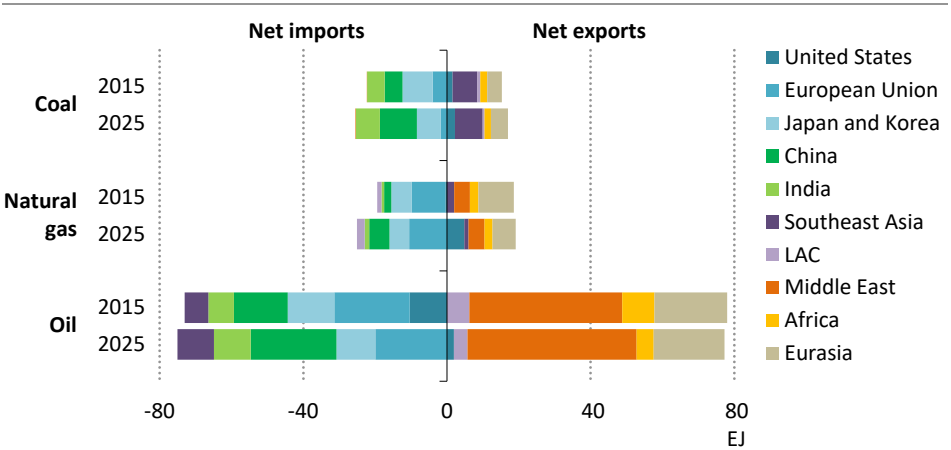
demand growth, with China accounting for a large share of the increase; other increases in demand were concentrated in resource-rich regions, notably Eurasia, the Middle East and the United States. Demand for renewables accelerated more strongly during 2015-2025 than demand for any other energy source. As with coal and natural gas, China was the largest source of growth in renewables demand over the last decade; India and Southeast Asia were the second and third largest. Unlike other sources of energy, demand for renewables has increased in nearly all regions over the past two decades.

The increasing diversity of demand growth across regions and fuels has combined with evolving patterns of energy production to deliver some major changes in energy trade (Figure 8.2). While some regions have reduced their exposure to imported energy by developing their own resources, others have seen import requirements increase. More than 85% of oil demand in India is met through imports, rising to over 90% in the European Union and nearly 100% in Japan and Korea. Natural gas import dependence reaches around 40% in China, 90% in the European Union and almost 100% in Japan and Korea. By contrast, endowed with abundant resources, the United States has become the world's largest producer of oil and natural gas, and it has become a net exporter of both fuels over the past decade. Eurasia and the Middle East remain highly export-oriented, although Russia's natural gas exports have become increasingly constrained in recent years.

Figure 8.2 ▷ Net energy trade by region, 2015 and 2025



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The United States has emerged as a net exporter of oil and natural gas, while the largest energy importers are concentrated in Asia and the European Union

Note: Intra-regional trade flows are not included in net trade.

Energy demand is characterised by wide disparities across regions, and this is reflected in ownership and activity indicators (Figure 8.3). For example, car ownership in advanced economies, such as the European Union, Japan, Korea and the United States, is 6 to 9 times

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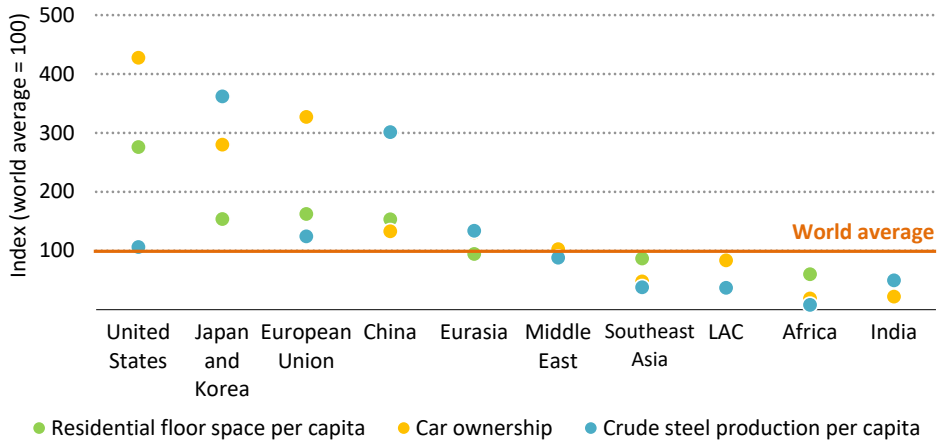
higher than in Southeast Asia and 15 to 20 times higher than in Africa or India. As emerging market and developing economies grow steadily, catching up on some of these indicators, their energy consumption increases in all scenarios. This rate of increase is shaped by different fuel and technology choices, which determine overall energy trajectories.

Figure 8.3 ▷ Indicators of residential, transport and industrial activity in selected regions, 2025



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There are wide disparities in residential, transport and industrial activity indicators across countries and regions

Global electricity demand has grown around twice as fast as total energy demand over the last decade. Today, electricity accounts for 23% of final energy consumption. Because electricity is much more efficient than fossil fuel technologies, it meets a much larger proportion of useful energy demand – almost 40%. Its role in economic activity is even greater, particularly in high-value sectors such as advanced manufacturing, digital services and artificial intelligence (AI), and it was the main energy source for sectors representing over 45% of the global economy in 2025 (IEA, 2026a).

Japan and Korea have long maintained high electrification rates, and China is now closing the gap after rapid progress over the past 20 years (Figure 8.4). These countries share a high dependence on fossil fuel imports, which has contributed to their electrification push. Southeast Asia has also electrified rapidly in recent years. Although progress has been slower, this is also the case in the European Union, where imported fuels account for around 60% of total energy demand, costing approximately 340 billion euros (EUR) in 2025. Around 80% of the European Union's electricity demand is met by domestic resources, particularly renewables and nuclear power, which is a higher proportion than in most other regions. In regions with plentiful fossil fuel resources, the rate of electrification has grown at a relatively moderate pace.

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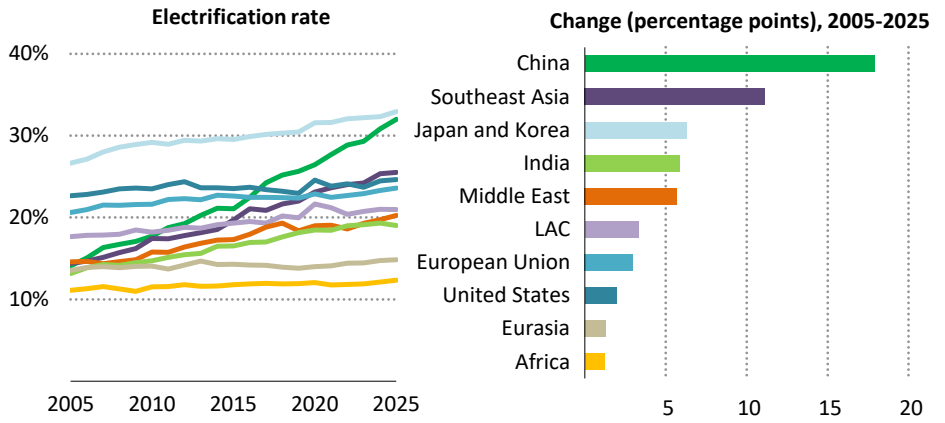
Figure 8.4 ▷ Economy-wide electrification rates and percentage point changes in selected regions, 2005-2025



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Global electricity demand has grown around twice as fast as energy demand, but electrification among import-dependent economies varies greatly

Note: The electrification rate measures the share of electricity in total final energy consumption.

GDP growth and emissions have diverged in many regions over the past decade (Figure 8.5). In many economies, GDP has continued to expand, while energy-related carbon dioxide (CO_2) emissions have plateaued or declined as a result of improvements in energy efficiency, structural economic changes and the growing deployment of low-emissions energy technologies. This trend is even more pronounced for major air pollutants such as fine particulate matter ($PM_{2.5}$), emissions of which have fallen across a wider range of regions where GDP has risen, supported by cleaner fuels, tighter environmental regulations and advances in pollution control technologies. However, the divergence between the growth of GDP and emissions has not been enough to prevent the absolute level of emissions from increasing in some fast-growing economies, with CO_2 emissions rising by around 20% in China between 2015 and 2025 and by more than 45% in both India and Southeast Asia over the same period. There are also some countries where $PM_{2.5}$ emissions have continued to rise in absolute terms over the last decade.

The sections that follow explore the regional trajectories for energy demand, supply, investment and emissions under the Current Policies Scenario (CPS) and the Stated Policies Scenario (STEPS). Where relevant, they consider the Additional Response Case (ARC), which examines the implications of measures that governments may adopt to strengthen energy security and resilience in light of the 2026 energy crisis. They also include a deep dive into a pertinent topic for each region.

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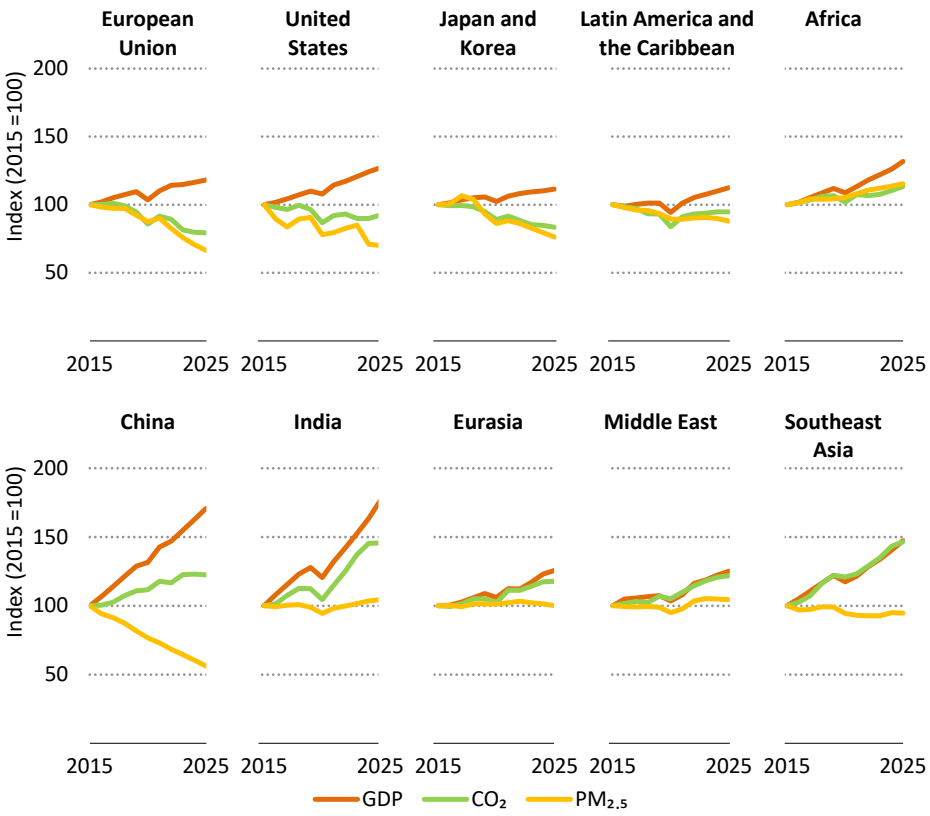
Figure 8.5 ▷ GDP, energy-related CO_2 and air pollutant emissions, 2015-2025



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Emissions are increasingly diverging from economic growth across regions

Notes: GDP = gross domestic product; CO_2 = carbon dioxide. $PM_{2.5}$ = particulate matter with a diameter of 2.5 micrometres or less. It is a commonly measured air pollutant.

The Net Zero Emissions by 2050 (NZE) Scenario is a global pathway, so it does not feature directly in the regional sections. However, decarbonisation pathways and emissions reduction goals provide crucial orientation for policy makers in many parts of the world and a powerful stimulus for them to seek a faster transformation of the energy system.

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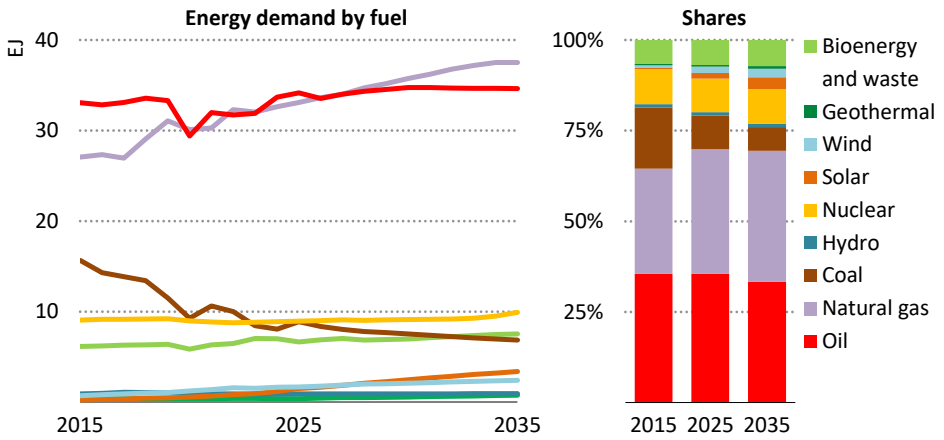
8.2 United States

In the CPS, total energy demand in the United States grows by around 8% from 2025 to 2035, an acceleration compared to the previous decade. This reflects economic growth, rising electricity demand and a push to expand the production and use of domestic energy. Together with a series of executive orders and regulatory changes, the One Big Beautiful Bill Act (OBBBA), enacted in 2025, has reframed federal energy policy around the pursuit of "energy dominance" and efforts to make the most of the country's oil, natural gas, coal, nuclear and geothermal resources.

Figure 8.6 ▷ Total energy demand by fuel in the United States in the CPS, 2015-2035



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Fossil fuels and nuclear are set to account for about 85% of the US energy mix in 2035, with natural gas overtaking oil as the biggest source of energy

Fossil fuels continue to dominate the US energy mix in the CPS, meeting about 75% of total energy demand in 2035, down slightly from 79% in 2025 (Figure 8.6). Oil continues to make a major contribution, meeting roughly one-third of total energy demand through to 2035. Natural gas demand continues to grow, rising from around 954 billion cubic metres (bcm) in 2025 to 1 080 bcm by 2035; natural gas edges past oil to become the largest single fuel in the energy mix, driven above all by strong growth in gas use for power generation. Coal continues its structural decline as ageing coal plants are retired, falling by around a quarter by 2035, or about 70 million tonnes of coal equivalent (Mtce), even as measures to preserve and invest in new capacity slow the pace of decline. Electricity generation from nuclear power remains broadly stable in the near term before a new wave of large reactors and small modular reactors starts to come online, lifting supply by over 10% to 2035 (though faster growth is projected from 2035 to 2050). Renewables grow fastest, with solar photovoltaic (PV) generation more than doubling to 2035, geothermal almost doubling from a small base

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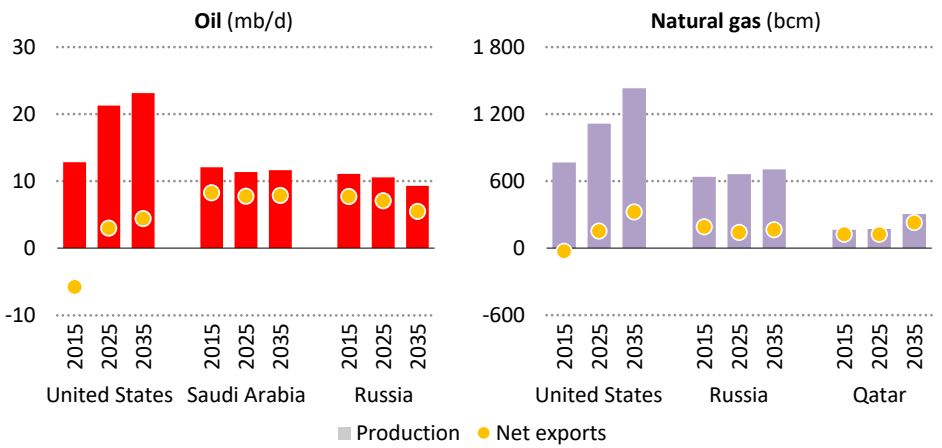
and wind rising by more than 40%. Together with bioenergy, they lift the share of total energy demand covered by renewables from around 11% to 14% by 2035, though growth is slower than in recent years.

Domestic oil and gas production is at the centre of the US energy policy agenda, with the OBBBA and a range of executive orders supporting expanded oil and gas leasing on federal lands and offshore areas, accelerating permitting processes and reducing regulatory requirements for energy development. Over the last decade, the United States has shifted from being a net importer of both oil and natural gas to confirming its position as the world's largest producer of each and becoming a net exporter of both fuels (Figure 8.7). In 2015, the United States was a net importer of around 6 million barrels per day (mb/d) of oil and 27 bcm of natural gas. By 2035, net exports reach 4.4 mb/d of oil and over 320 bcm of gas in the CPS.

Figure 8.7 ▷ Oil and natural gas production and net exports in the United States and other major exporters in the CPS, 2015-2035



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The United States, until recently a net importer of oil and natural gas, is now a major exporter of both, and production and exports are set to expand further to 2035

Note: mb/d = million barrels per day; bcm = billion cubic metres.

Oil production rose from 12.8 mb/d in 2015 to 21 mb/d in 2025. Output continues to increase in the CPS into the early 2030s before levelling off, reaching 23 mb/d in 2035. This would mean the United States remains by far the world's largest oil producer, ahead of Saudi Arabia (about 12 mb/d) and Russia (9 mb/d). Exports continue to rise even as production plateaus, with gross crude and product exports exceeding 7 mb/d by 2035, and the export share of output remaining stable at about one-third. Despite strong domestic demand for oil, the United States is the third-largest net oil exporter in 2035, behind Saudi Arabia (8 mb/d) and Russia (6 mb/d). This gives the United States an influential role in global oil markets, adding diversity and flexibility to global supply and helping to cushion the impact of potential disruptions elsewhere.

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In the CPS, natural gas production expands by nearly 320 bcm over the next decade, reaching more than 1 400 bcm in 2035. This increase of nearly 30% outpaces robust domestic demand growth and extends the position of the United States as the world's largest gas producer, well ahead of Russia and Qatar. Net gas exports rise to over 320 bcm by 2035, with new liquefied natural gas (LNG) capacity accounting for almost all of the growth. LNG exports approach 310 bcm in 2035, or more than 20% of total gas production, even as US pipeline-based exports stay broadly flat. This places the United States ahead of Qatar as the world's largest gas exporter, and well ahead of Russia. The scaling up of US LNG production looks set to reshape global gas markets, easing market tightness and giving importers greater optionality and security.

Powering US electricity demand growth

For the first time since the early 2000s, the United States is facing rising rather than flat electricity demand, with total electricity demand in the CPS growing by over 1 000 terawatt-hours (TWh), or by one-quarter, between 2025 and 2035, driven largely by data centres, electrification and a resurgence in domestic manufacturing.

In the United States, data centres are the single most important driver of this expansion in electricity use, with their demand in the CPS projected to more than quadruple from around 200 TWh in 2025 to over 830 TWh by 2035. However, there is a high degree of uncertainty about the pace and scale of data centre expansion, which depends, among other things, on the evolution of computing efficiency and the speed and scale of AI development and use (IEA, 2026b).

The ability of the electricity system to accommodate this potential demand growth is emerging as a critical constraint for the AI industry. New power capacity, transmission infrastructure, transformers and grid connections are often developed on much longer timelines than data centres themselves. Physical bottlenecks in electricity networks and manufacturing supply chains are already slowing some projects, while grid operators face the challenge of planning for large additional loads whose timing and magnitude remain uncertain. Where data centres cluster (Figure 8.8), the sector could account for a large share of local electricity demand, placing growing pressure on network capacity and putting a premium on efficient grid expansion and connection processes. Public acceptance of data centres is also emerging as an important consideration in some parts of the United States.

In the CPS, natural gas-fired generation increases by almost 500 TWh to 2035 as existing grid-connected plants run more often, new capacity is connected to the grid and developers co-locate new, dedicated gas generators with large data centres (Figure 8.9). The rapid expansion of data centres is exposing bottlenecks in the supply of new gas-fired capacity; new orders reached a 25-year high in 2025, leading to long lead times for turbines as constraints in manufacturing capacity and broader supply chain pressures slow the deployment of new capacity. Despite this, gas-fired generation provides nearly 45% of all additional generation to 2035 and maintains its share of the US electricity mix at around 40%.

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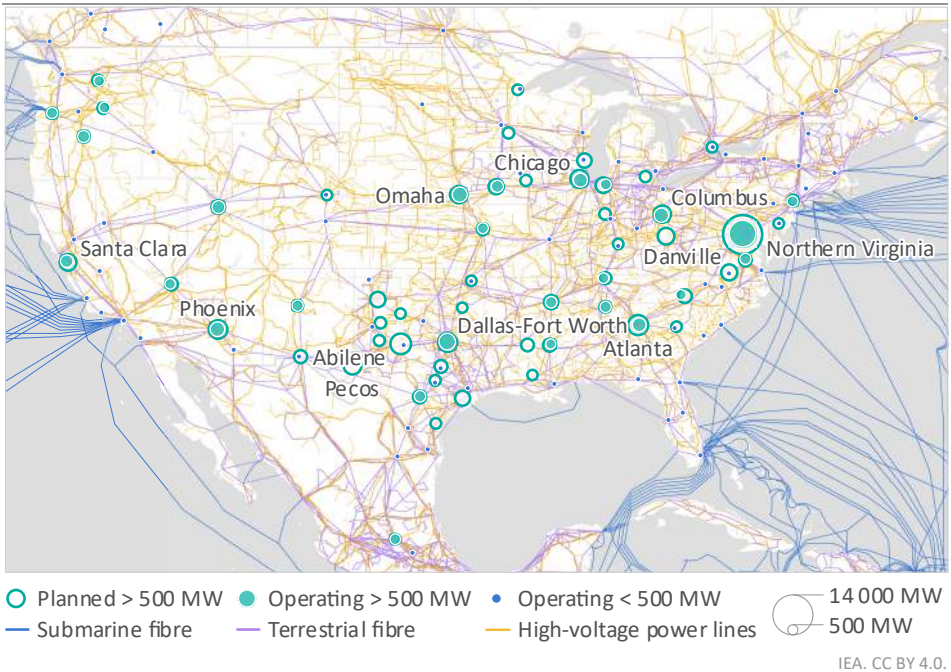
Coal-fired power generation remains higher over the outlook period than projected in the CPS in the *World Energy Outlook 2025*, due to new measures to keep plants open that were scheduled to close, in order to bolster network reliability and help meet load growth. However, it still declines by around a quarter to around 620 TWh by 2035.

Figure 8.8 ▷ Map of data centre hubs alongside associated power and digital infrastructure in the United States, 2026



Data centre clusters in the United States are putting pressure on electricity networks and exposing bottlenecks in the supply of new gas turbines for power generation

Notes: Data centre hubs represent the capacity-weighted centroid of data centre clusters within 100 km of each other and totalling over 500 megawatts (MW) of installed capacity. High-voltage power lines reflect the high-voltage power lines available from OpenStreetMap at the time of data extraction and are provided as is.

Sources: IEA analysis of data centre location data from Omdia's Data Center Building Tracker – 1H26 (2026); power line data from OpenStreetMap (2026); communications infrastructure data from the ITU Broadband Mapping programme (2025); submarine fibre-optic network data from TeleGeography (2021).

Nuclear power generation is lifted by a wave of new large reactors and small modular reactors (SMRs) after 2030, already raising output by over 10% to 2035 in the CPS. Momentum for nuclear is building due to federal support in the form of tax credits, loan guarantees and direct support for existing reactors, and to strong demand from technology companies seeking to secure electricity supply for data centres, with more than 40 gigawatts (GW) of SMRs linked to announced procurement agreements.

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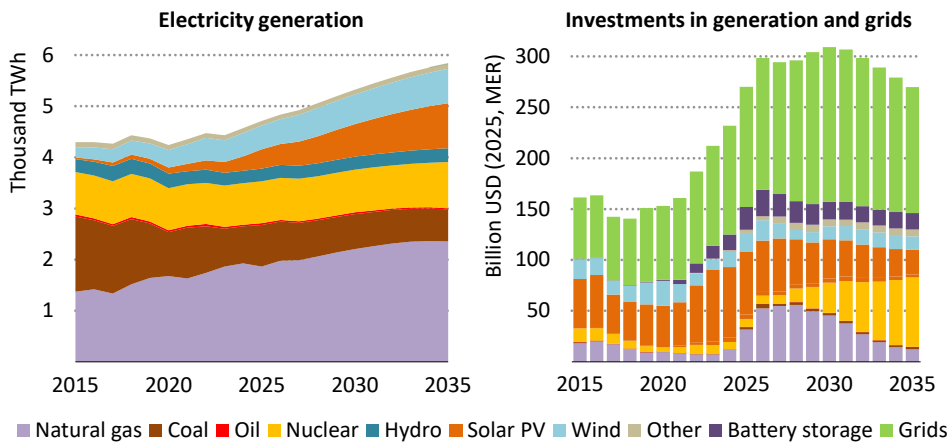
Taken together, renewables grow the most in absolute terms, with the share of solar PV and wind in total generation rising from 18% in 2025 to over 25% in 2035, though the accelerated phase-out of wind and solar tax credits under the OBBBA tempers their growth compared to recent years. Solar PV remains the primary driver of growth in renewables, with geothermal playing a growing role and offshore wind a more modest one.

Figure 8.9 ▷ Electricity generation by source and power sector investments in the United States in the CPS, 2015-2035



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Rising demand is met primarily by renewables and natural gas; grids account for about 50% of the investment to 2035

Notes: TWh = terawatt-hour; PV = photovoltaics; MER = market exchange rate. Other includes bioenergy, waste, geothermal, concentrating solar power and marine power.

As US electricity demand accelerates, power sector investment is shifting towards grids and dispatchable capacity. Grid spending rose from USD 73 billion in 2020 to USD 118 billion in 2025, and, in the CPS, it increases to an average of close to USD 140 billion over the next decade as utilities connect new generation and large loads, replace ageing assets, ease congestion and strengthen resilience. Part of this increase reflects higher project costs due to constrained manufacturing capacity; rising prices for transformers, cables and key materials; and shortages of skilled labour. Investment in gas-fired generation rose from around USD 7 billion annually in 2022-2023 to USD 12 billion in 2024 and USD 32 billion in 2025, and it continues to rise in the near term, peaking at over USD 50 billion before 2030, as data centre demand drives project approvals and equipment orders. Annual wind and solar PV investment declines as weaker federal support slows deployment. Nuclear investment rises significantly from around 2030 as large-scale, SMR and advanced reactor projects gather pace. Battery storage investment moderates from the all-time high projected in 2026 due to continued cost declines, even as deployment remains high.

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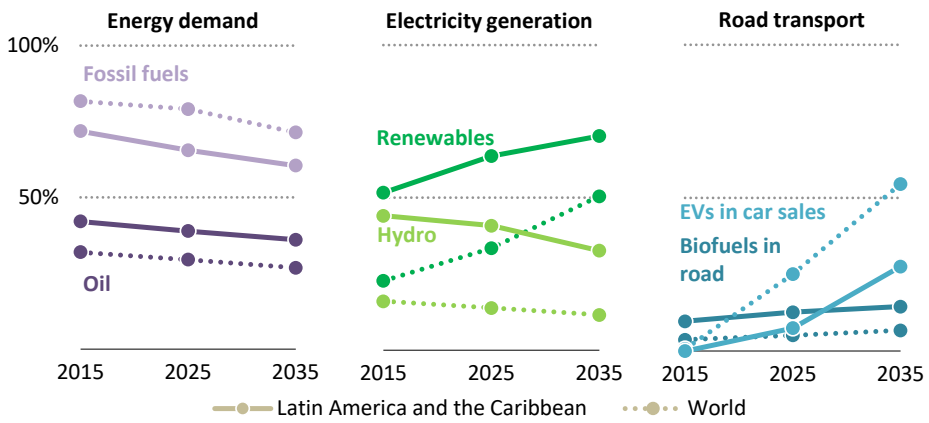
8.3 Latin America and the Caribbean

Latin America and the Caribbean (LAC) has a large renewables base built on hydropower and biofuels. Renewables account for around two-thirds of the regional power mix, a share twice the global average, and supply all or almost all of the electricity in countries such as Costa Rica and Paraguay. As the region faces more frequent adverse weather events, droughts and weather variability linked to El Niño and La Niña, which can affect hydropower generation, energy system resilience is becoming a pressing issue. This is prompting most LAC countries to accelerate efforts to diversify their energy mix and develop energy efficiency measures while implementing climate pledges.

While the global share of fossil fuels in energy demand has stayed close to 80% since 2015, the share in LAC fell from 72% to 65% between 2015 and 2025 (Figure 8.10). Oil still accounts for just under 40% of the regional energy mix, compared with 30% globally, reflecting its importance in the transport and other end-use sectors. However, oil demand grows by only 0.45 mb/d by 2035 in the STEPS, less than half as fast as the region's total energy demand.

Figure 8.10 ▷ Share of fuels by sector and EV share in car sales in LAC and the global average in the STEPS, 2015-2035



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The development of renewables in Latin America and the Caribbean has kept reliance on fossil fuels lower than the global average

Note: EV = electric vehicle.

In the power sector, sustained policy support and price-competitive technologies lift the share of renewables in the generation mix to 70% by 2035 in the STEPS, compared with a projected share of just 50% globally. Hydropower provided around 45% of the region's power in 2015, but solar PV and wind have driven most of the growth over the last decade, and they continue to do so in the STEPS.

LAC has also been an early mover in biofuels, whose share in regional road transport is more than twice the global average. This reflects decades of policy support – particularly in Brazil,

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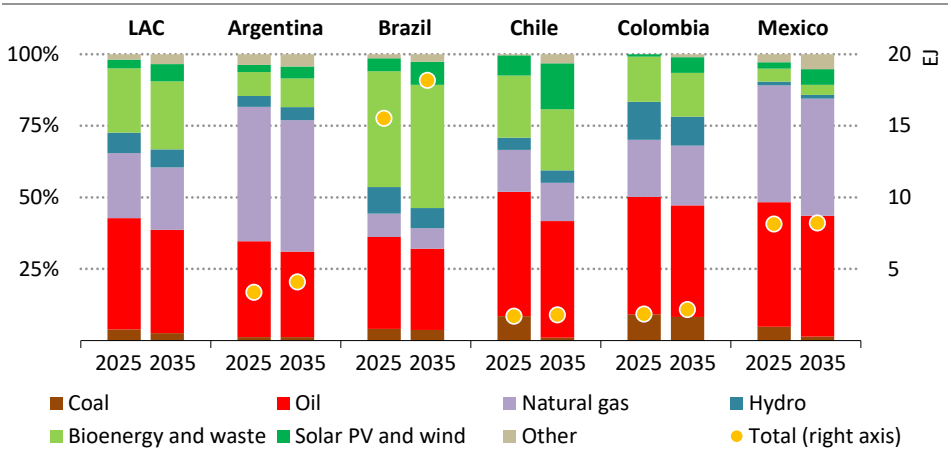
where the mandatory ethanol blend was temporarily increased in August 2026 from 30% to 32% in response to the 2026 energy crisis (Brazil, Ministry of Mines and Energy, 2026). Chile has one of the ten largest electric bus fleets globally. Other countries in the region, such as Brazil and Colombia, also have sizeable electric bus fleets, with approximately 2 000 buses each. The uptake of electric cars rose in 2025 in response to more competitively priced vehicles and policies, including tax exemptions in Colombia, Costa Rica and Uruguay, fuel-economy standards in Chile, and Brazil's MOVER (Mobilidade Verde e Inovação) programme. In the STEPS, a quarter of new car sales in LAC are electric by 2035.

National trajectories diverge in the STEPS, reflecting different resource endowments and levels of imports, though all countries in the region see rising shares of solar PV and wind up to 2035 (Figure 8.11). Fossil fuel importers have strong incentives to reduce import bills through energy efficiency, domestic renewables and electrification (Box 8.1). In countries such as Chile, solar PV and wind expansion also supports a nascent low-emissions hydrogen industry. In Brazil, renewables increase from a very high base, while biofuel production rises from 0.6 million barrels of oil equivalent per day (mboe/d) today to nearly 1 mboe/d by 2035, strengthening Brazil's position as a global leader. Argentina continues to rely heavily on natural gas for power and industry, heating in buildings, and the 1.7 million cars it fuels; its domestic production is projected to expand with the development of the Vaca Muerta field.

Figure 8.11 ▷ Total energy demand by fuel and country in LAC in the STEPS, 2025-2035



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Renewables continue displacing fossil fuels, especially in importing countries, though oil remains the main fuel in many countries

Note: Other includes nuclear, solar thermal and geothermal.

The region also includes major oil and gas exporters that between them account for 10% of global oil supply and 4% of natural gas supply. In the STEPS, oil production in LAC increases by around 15% in the next decade – doubling in Guyana; rising in Argentina, Brazil and

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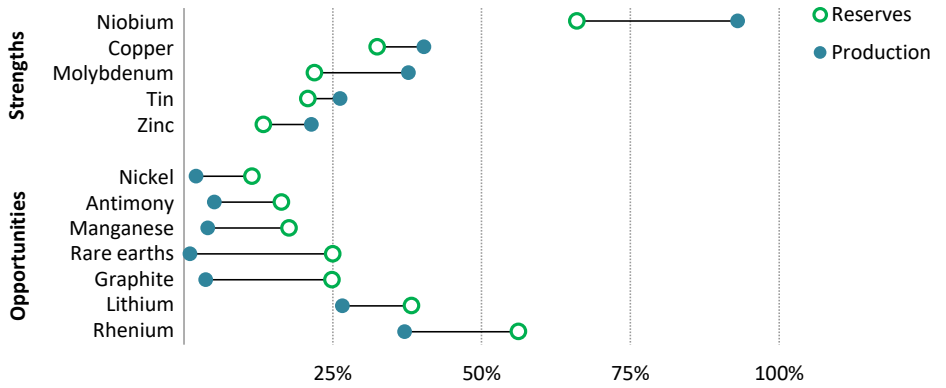
Venezuela; and declining in Colombia and Mexico. Natural gas production in the region remains broadly constant until 2035, but the balance between countries varies; the biggest increase comes in Argentina, which sees a 45% growth in production.

LAC's pivotal role in critical mineral supply

LAC is endowed with sizeable reserves of many minerals that are critical for energy and other strategic sectors, such as high-tech industries and aerospace. These include base metals such as copper, zinc and tin; battery minerals such as lithium, graphite, manganese and nickel; and strategic minor minerals such as niobium, rhenium, molybdenum and rare earths (Figure 8.12). Globally, the energy sector is set to drive strong growth in demand for critical minerals in the next decade. In the STEPS, global lithium demand increases 2.5-fold by 2035, with the energy sector accounting for 95% of the increase.

Figure 8.12 ▷ Share of global reserves and production for selected minerals in LAC countries, 2025



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Countries in Latin America and the Caribbean have significant reserves of multiple critical minerals, and there is scope to develop them further to meet growing global demand

Copper – essential for electricity grids and electric vehicles (EVs) in particular – plays a central part in the economies of some LAC countries, accounting for half of Chile's exports and around one-third of Peru's. LAC countries cover two-fifths of global copper production by 2035 in the STEPS. Over the next decade, Argentina, Brazil and Chile lead an expansion of battery material production in LAC, with the region's lithium production set to increase by 50% by 2035. Brazil holds one-quarter of global graphite reserves, with production projected to grow by 60% by 2035. Brazil also plans to significantly scale up production of rare earths, which play a crucial role in energy, transport and AI. Strategic minor minerals produced in LAC countries, such as niobium and rhenium, are necessary for high-performance materials and steels that are used in the energy sector – from gas turbines to refinery equipment – and other strategic industries such as aerospace.

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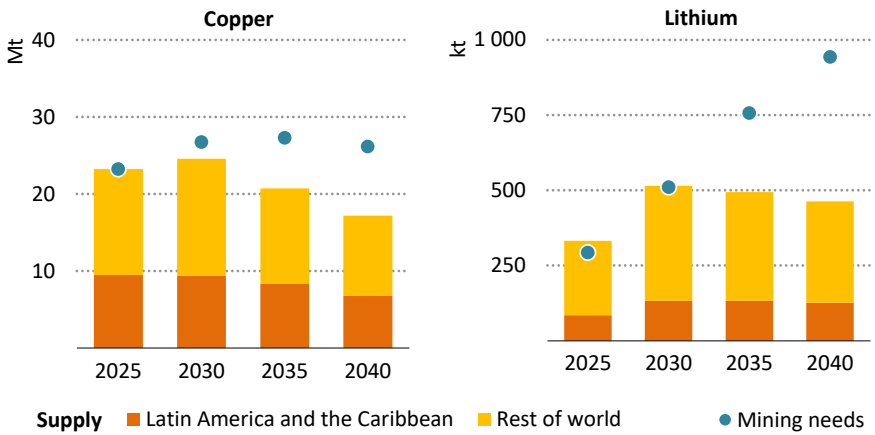
Global supply deficits for copper and lithium are expected to emerge around 2030 as demand continues to grow. By 2035, the supply gap in the STEPS amounts to around 25% of demand for copper and just over 30% for lithium (Figure 8.13). This points to an opportunity for LAC countries to help meet growing global demand and diversify highly concentrated global supply chains by further expanding mining production, including by increasing the output of existing mines through new technologies and efficiency gains. Recycling and the use of tailings – the waste material left over after initial extraction from ores – could help close the gaps further; innovations in exploration and extraction technologies, increasingly supported by AI, could unlock additional resources.

Figure 8.13 ▷ Copper and lithium mining needs and mined supply in the STEPS, 2025-2040



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Projected supply gaps for copper and lithium point to opportunities for the region to increase production

Notes: Mt = million tonnes; kt = kilotonnes. Mining needs are the demand net of reuse and recycling.

Developing local processing and refining alongside increased mining would bring larger economic benefits for the region (IEA, 2026c). Currently, LAC refines only around one-fifth of its mined output of key energy minerals, except for lithium, for which integrated chemical processing has already developed. If all the lithium, nickel, cobalt, graphite and rare earths that it produces were refined locally, and if two-thirds of its copper production were also processed within the region, the economic value generated could increase by nearly 45% from today's level, reaching around USD 220 billion by 2035. Embracing this opportunity requires action to address high financing costs, infrastructure gaps in power and water, and technology and skills constraints, together with steps to strengthen engagement with local stakeholders. Enhanced regional integration and stronger linkages between different parts of the supply chain would help to maximise the value of these resources.

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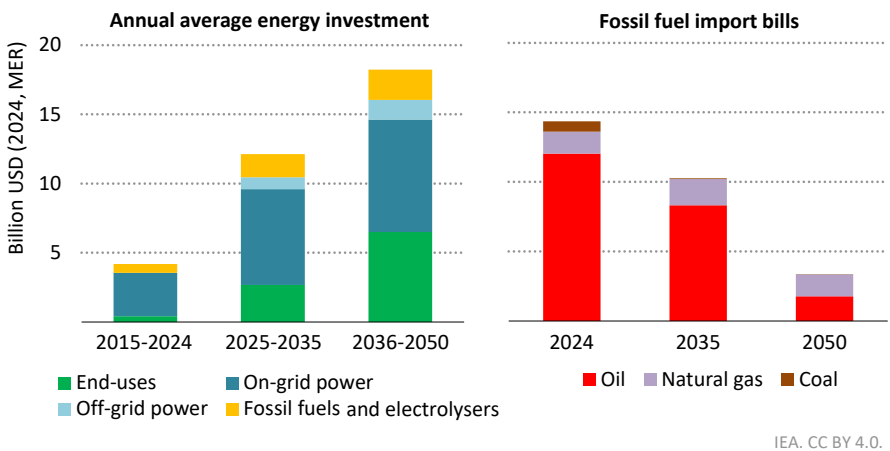
Box 8.1 ▻ Chile: a long-term energy transition pathway

Chile has few domestic fossil fuel resources and has historically relied heavily on imports to meet its energy demand. Despite rapid growth in renewable electricity, fossil fuels met two-thirds of total energy demand in 2024, with oil alone accounting for 43%. Most of these fuels are imported, and they cost around USD 14 billion in 2024. This cost could increase by a further 20% in 2026 (CREA, 2026). At the same time, Chile has some of the world's best solar and wind resources, along with an essential role in global supply of some critical minerals, such as copper, lithium and molybdenum.

Figure 8.14 ▻ Average annual energy investments and fossil fuel import bills in the IEA's Chile 2050 Energy Transition Roadmap, 2015-2050



Savings on fossil fuel import bills offset part of the additional investment required for Chile's energy transition

Source: IEA Chile 2050 Energy Transition Roadmap (2025).

Harnessing these resources requires changes to Chile's energy system. In the pathway explored in the IEA's Chile 2050 Energy Transition Roadmap (IEA, 2025), electricity rises from less than a quarter of final energy consumption today to more than half by 2050 as EVs, industrial electrification and electric heating displace fossil fuels. Meanwhile, rapidly expanding solar and wind generation is supported by new grids, storage and other flexible resources. Such a transition would require a rise in annual energy investment from around USD 4.5 billion over the past decade to nearly USD 13 billion through to 2035. The impact of this pathway on energy trade is substantial: Chile's expenditure on fossil fuel imports falls from around USD 14 billion in 2024 to USD 3 billion by 2050 (Figure 8.14). The transition also creates more new jobs in power, critical minerals and energy efficiency than are lost in fossil fuel-related activities. Recent Chilean planning reinforces the direction of travel, while recognising that the transition will depend on sustained infrastructure development (Chile, Ministerio de Energía, 2026).

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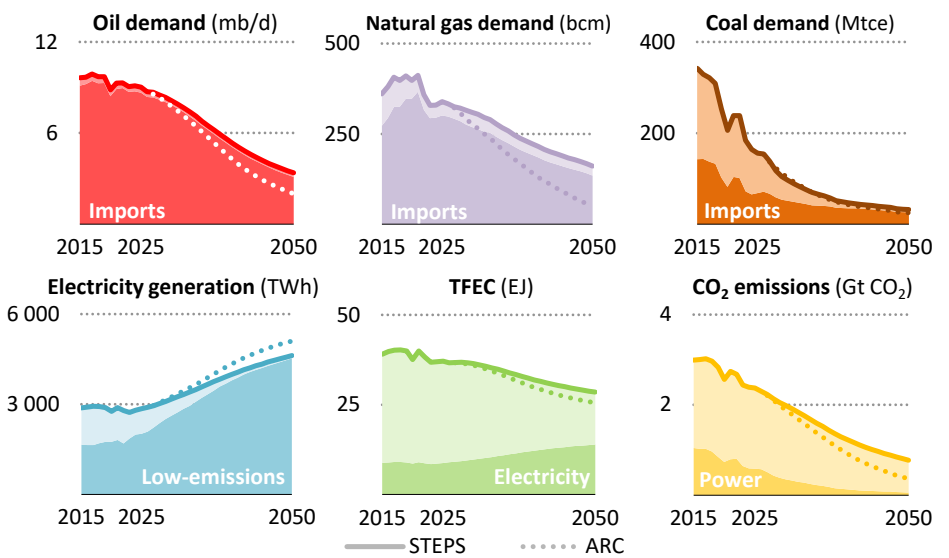
8.4 European Union

The European Union is a leader on clean energy, with progress accelerating after the 2022 energy crisis as renewable electricity generation expanded and energy-related CO_2 emissions fell. However, it remains heavily exposed to imported fossil fuels: domestic sources provide around 80% of electricity generation, but they account for only 40% of total EU energy demand. At the same time, energy system costs remain higher than in other advanced economies. These vulnerabilities have been highlighted by renewed risks to energy trade through the Strait of Hormuz, and they mean that the European Union's energy transition is bound together with considerations of energy security and affordability. The European Union is now exploring options to reduce fossil fuel imports further and cut energy costs for households and businesses, including through reforms to network charges and energy taxation and through targeted changes to the Emissions Trading System.

Figure 8.15 ▷ Key energy system trends in the European Union in the STEPS and the ARC, 2015-2050



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Efficiency gains and electrification are set to reshape the EU energy system, shifting energy demand towards domestically supplied electricity and lowering emissions

Note: Mtce = million tonnes of coal equivalent; Gt CO_2 = gigatonnes of carbon dioxide; TFEC = total final energy consumption; STEPS = Stated Policies Scenario; ARC = Additional Response Case.

In the STEPS, the European Union continues to reduce its exposure to fossil fuels (Figure 8.15). Oil and natural gas demand each fall by over 20% from 2025 levels by 2035, and coal demand shrinks by close to 60%. As a result, fossil fuel imports decrease significantly, reducing exposure to volatility in global energy markets. Meanwhile,

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low-emissions sources continue to expand their role in the power sector. Renewables and nuclear account for 90% of electricity generation by 2035, up from 70% in 2025. Wind and solar PV provide 70% of power capacity additions over the period. At the same time, progress on energy efficiency and the electrification of end-uses reduces total final energy consumption.

Even so, progress in the STEPS is not enough to meet the European Union's longer-term climate and energy security ambitions, including the objectives of reaching net zero greenhouse gas emissions by 2050 and of cutting greenhouse gas emissions to 90% below 1990 levels by 2040. In the ARC, the European Union's response to the 2026 energy crisis is strongly aligned with its transition goals. Stronger policy implementation and faster deployment of clean energy technologies enable the European Union to reduce the gap, and energy-related CO_2 emissions fall by 75% by 2040 relative to 1990 levels. Renewable capacity additions are over 15% higher by 2030 in the ARC than in the STEPS, while stronger energy efficiency improvements reduce demand and faster fuel switching increases electricity's share in final energy consumption.

Achieving this faster transition depends not only on adding new generation but also on strengthening the electricity system. Greater deployment of renewables requires increased investment in grids and interconnections, storage and other flexibility resources to make the most of variable generation and ensure system reliability. In the ARC, the doubling of electricity generation from low-emissions sources by 2040 is accompanied by average annual investment in electricity transmission and distribution grids of USD 120 billion to 2040, which is more than twice the average level seen over the past 15 years. Recent initiatives such as the EU Grids Package and Clean Energy Investment Strategy aim to support these investments and reduce bottlenecks.

As decarbonisation in the electricity sector advances, larger gains in energy security and emissions reductions increasingly depend on replacing fossil fuels in end-use sectors. Accelerating electrification therefore becomes a critical link between a cleaner power sector and the achievement of the European Union's objectives on competitiveness, affordability, energy security and decarbonisation. The European Commission's Electrification Action Plan, published in July 2026, outlines measures to advance electrification across end-use sectors (European Commission, 2026).

Meeting the European Union's electrification target

As part of the Electrification Action Plan, the European Commission has proposed an EU-wide target of a 46% electrification rate by 2040. This target is well above the European Union's current electrification rate of 24% – a rate that has remained broadly stable over the past decade and is substantially lower than electrification rates in comparable advanced economies with limited fossil fuel resources, such as Japan and Korea (Figure 8.4).

The European Union enters the next phase of electrification with several structural advantages. It already generates a high share of low-emissions electricity compared with

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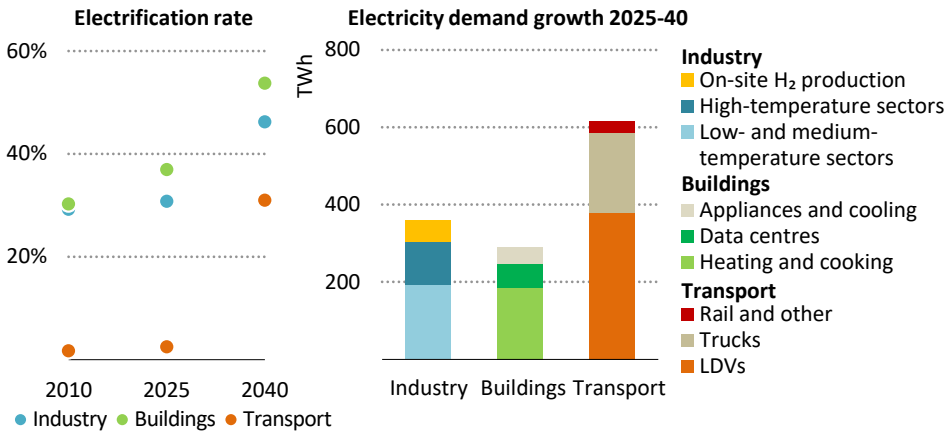
other advanced economies, which provides a solid foundation for cutting emissions as buildings, industry and transport electrify. Its integrated single market, interconnected grid and harmonised regulatory framework form a strong basis for increasing electrification efficiently and reliably. Its established industrial capabilities, skilled workforce and world-class training programmes position it well to expand domestic clean energy supply chains and meet growing demand for electrification technologies.

In the ARC, the electrification rate reaches 46% by 2040[1], reflecting both wider use of electricity and substantial reductions in final energy consumption through efficiency improvements. As total consumption falls, each additional unit of electricity accounts for a larger share, amplifying its effect on the electrification rate (Figure 8.16).

Figure 8.16 ▷ Electrification rate and electricity demand growth by sector and sub-sector in the European Union in the ARC, 2010-2040



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Realising the European Union's electrification goals would add over 1 000 TWh to electricity consumption, greater than the combined electricity use of France and Germany today

Notes: H_2 = hydrogen; LDV = light-duty vehicles. Low- and medium-temperature sectors refer to non-energy-intensive industries, certain chemicals products and the paper sector with heat demand primarily below 400 degrees Celsius. High-temperature sectors aggregate other industries. Other includes two/three-wheelers and buses.

The transport sector accounts for roughly half of EU electricity demand growth to 2040. In the ARC, electric car sales more than triple and the electrification rate in transport rises from 2% today to 31% in 2040 (Figure 8.17). Meanwhile, the electrification rate in industry rises from 31% to 46% by 2040 as heat is electrified. Low-temperature heat, which can be entirely electrified by using heat pumps, represents only around one-sixth of industrial energy

[1] Electrification rate calculated using the European Commission's Electrification Action Plan methodology. This corresponds to an electrification rate of 45% under the methodology used throughout this report.

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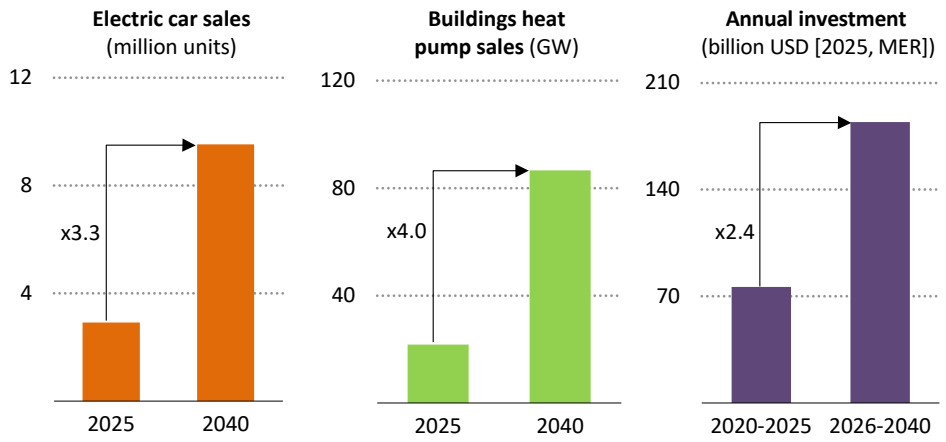
demand. In the ARC, heat pumps are also used at higher temperatures where a source of waste heat is available. Medium- and high-temperature processes can be electrified using technologies such as electric boilers, resistance heating, induction heating and arc furnaces. At 37%, the electrification rate in buildings is the highest of any sector today, but it stands at just 10% for space heating. In the ARC, the electrification rate for space heating grows to more than 20% by 2040, boosting the overall electrification rate in buildings above 50%. Electric equipment supplies almost 40% of useful energy for space heating: heat pumps account for the majority of this equipment, and annual heat pump sales quadruple from current levels.

Figure 8.17 ▷ Key indicators to reach the European Union's electrification target in the ARC, 2020-2040



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Average annual investment in end-use electrification more than doubles as households and businesses switch to electric vehicles and heat pumps in the ARC

Notes: GW = gigawatt. Annual investment only includes electrification investment in end-use sectors. Electric car sales include only newly sold passenger vehicles and exclude registrations of imported used vehicles.

Realising these broad technology shifts hinges on overcoming the range of economic, infrastructural and regulatory barriers that have so far prevented faster electrification in the European Union. One key issue is the cost of electricity. For example, residential heat pumps are much more efficient than gas boilers, but they are currently at least as expensive to own in 11 EU countries totalling two-thirds of EU heating demand, including France, Germany and Poland. In 13 EU countries, electricity remains at least three times more expensive than gas. A substantial share of EU energy demand cannot be electrified at current electricity prices without raising operating costs (Figure 8.18). As part of its Electrification Action Plan, the Commission has proposed an amendment to the Electricity Regulation which would require member states to reduce any tax disadvantage for electricity relative to natural gas.

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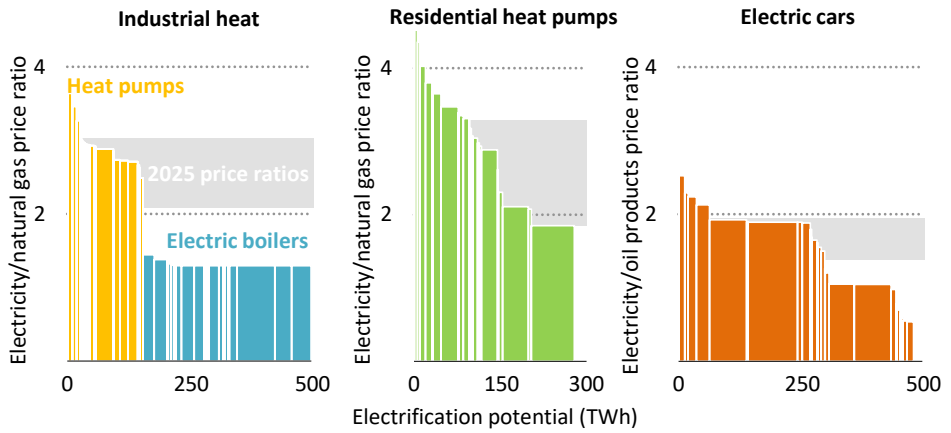
Figure 8.18 ▷ Potential for cost-competitive electrification at different electricity-to-fossil fuel price ratios by technology in the European Union, 2025



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While a large share of EU energy demand can already be electrified without increasing operating expenses, broader electrification relies on lower electricity costs

Note: Electricity-to-gas price ratio based on residential, commercial and industrial prices weighted by electricity demand; for countries without reported residential gas demand, commercial gas prices are used.

Achieving operating cost parity alone is insufficient to accelerate electrification. High upfront costs discourage investment in electric technologies across all sectors. Today, the average payback period for a battery electric vehicle in the European Union is about eight years. High-temperature industrial applications require investment support to scale nascent electric technologies. Recognising this challenge, the European Commission has proposed establishing a EUR 100 billion Industrial Decarbonisation Bank. In the ARC, average annual investment in electrification in end-use sectors grows from USD 75 billion in 2020-2025 to USD 185 billion in 2026-2040.

Progress on electrification also depends on energy efficiency and demand-side flexibility measures that reduce the generation and grid capacity needed to accommodate new electric loads. In the Electrification Action Plan, the Commission proposes to reform network codes and require faster rollout of smart meters to promote flexible consumption across sectors.

If EU countries can overcome the challenges, achieving the proposed electrification target of 46% by 2040 would deliver major energy security and affordability benefits. In the ARC, lower consumption of fossil fuels reduces gas imports by 200 bcm and oil imports by 5 mb/d by 2040. Demand flexibility unlocks savings on energy spending, with electrified households – equipped with a heat pump and an EV – saving 10-15% on electricity bills.

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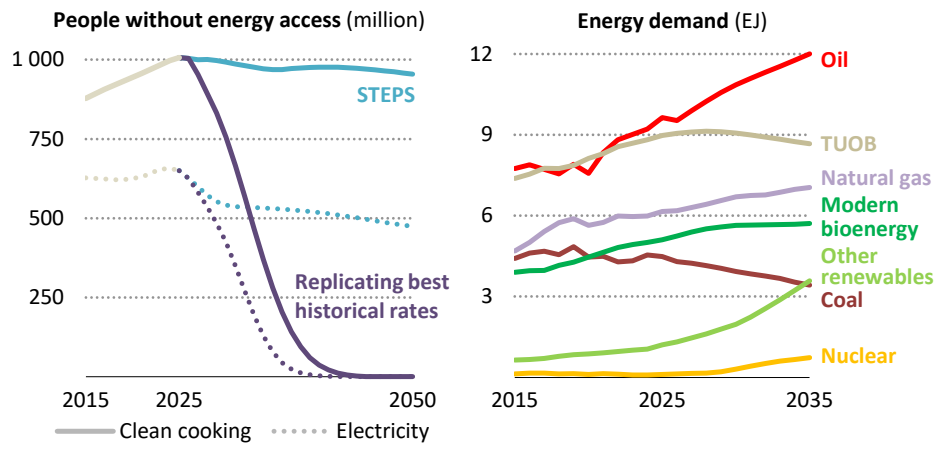
8.5 Africa

Following a prolonged period of uneven investment in Africa's energy sector and faltering progress on energy access, recent developments point to renewed momentum, even though the 2026 energy crisis has prompted some governments in Africa to focus in the near term on shielding consumers from higher fuel costs through measures such as tax reductions and fuel subsidies.

The number of people gaining access to electricity each year is set to rise in the STEPS from 24 million in 2025 to 40 million before 2030. Around 12 million people gained access to clean cooking in 2024. Early data indicate that this figure increased by 35% in 2025 and is set to rise to around 28 million by 2030. Faster progress could be achieved if comprehensive and integrated planning were put in place. Replicating the fastest rates of access achieved in the past would imply 60 million people gaining access to electricity and above 75 million to clean cooking each year, putting universal access within reach by 2035 and 2040, respectively.

Figure 8.19 ▷ People without access to energy and total energy demand by fuel in Africa in the STEPS, 2015-2050



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In the STEPS, energy access gaps persist, while fossil fuels and traditional biomass continue to dominate Africa's energy mix, albeit with rapid growth in renewable power

Notes: TUOB = traditional use of biomass. Replicating best historical rates = path to achieve universal access to clean cooking and electricity based on the best rates of progress achieved historically in comparable contexts as per the Accelerating Clean Cooking and Electricity Services Scenario and the Net Zero Emissions by 2050 Scenario. Other renewables include hydro, geothermal, solar and wind.

In Africa, total energy demand excluding the traditional use of biomass has increased by around 24% over the past decade, and it is projected in the STEPS to rise by a further 22% by 2035 (Figure 8.19). Despite rapid growth in renewable energy, fossil fuels are set to continue to dominate the energy mix, accounting for more than half of total energy demand by 2035.

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The use of bioenergy – mostly in the form of wood and charcoal – declines after 2030 in the STEPS as clean cooking efforts shift users to more efficient cooking solutions, but it still accounts for around one-third of total energy demand in 2035. Africa's coal demand – more than 80% of which is concentrated in South Africa, with Egypt, Morocco and Zimbabwe being other main users – has been stagnating since 2020, with gas and renewables increasingly displacing coal in the power sector.

Demand for electricity has increased by 25% since 2015, and it is set to be Africa's fastest-growing modern energy carrier through to 2035, with demand rising by a further 50% in the STEPS as more people gain access to electricity, the use of appliances increases, and industrialisation, telecommunications and digital infrastructure expand. Falling costs are opening new opportunities for EVs, reverse osmosis desalination and other technologies, although high upfront costs remain a barrier to wider adoption. Africa's EV fleet is still small, but it has grown from around 4 000 vehicles in 2020 to 150 000 in 2025, led by Ethiopia and other East African countries, with two/three-wheelers accounting for 70% of the growth in the continent. Meanwhile, desalination is set to become second only to cooling needs as a source of electricity demand growth in North Africa. Energy security concerns are also shaping electrification strategies as governments seek to reduce dependence on imported fuels. However, reliability challenges remain a major constraint, with weak grids and frequent supply interruptions limiting electricity use in many markets.

Africa is home to 60% of the world's best solar resources, but only 1% of global installed solar PV capacity. Solar PV has been the fastest-growing source of new electricity generation over the past decade, with total installed capacity – covering utility and small-scale systems – rising from 2 GW in 2015 to 39 GW in 2025. Although solar PV remains the largest source of capacity additions through to 2035 and is set to account for almost 40% of installed capacity, it still represents less than 20% of total electricity generation at that point. In some regions, investment in grids, storage and system flexibility and the development of grid codes and monitoring capabilities have not kept pace with solar deployment, raising concerns about the extent to which solar can be integrated effectively into current electricity systems.

Oil and gas remain central to Africa's outlook in our exploratory scenarios. Natural gas is the largest source of electricity generation, helping to balance solar PV, and in the STEPS, gas-fired generation rises by around 20% by 2035, largely in North Africa. Natural gas is also used extensively in producer countries for industrial activities. Oil demand is increasing, too – particularly in the fast-growing transport sector, although electrification is beginning to temper growth in oil use as solar-plus-battery systems become increasingly competitive with diesel generation for industrial and remote applications. Solar home systems now cost 50% less on a levelised cost basis than small diesel and petrol generators, and their growing deployment is reducing reliance on these generators, which amounts to 290 thousand barrels per day (kb/d) of oil products across sub-Saharan Africa, equivalent to almost 15% of the region's final consumption.

In the STEPS, oil production declines by 10% over the next decade, while natural gas production increases by 5%. Gas production gradually shifts from North Africa – responsible

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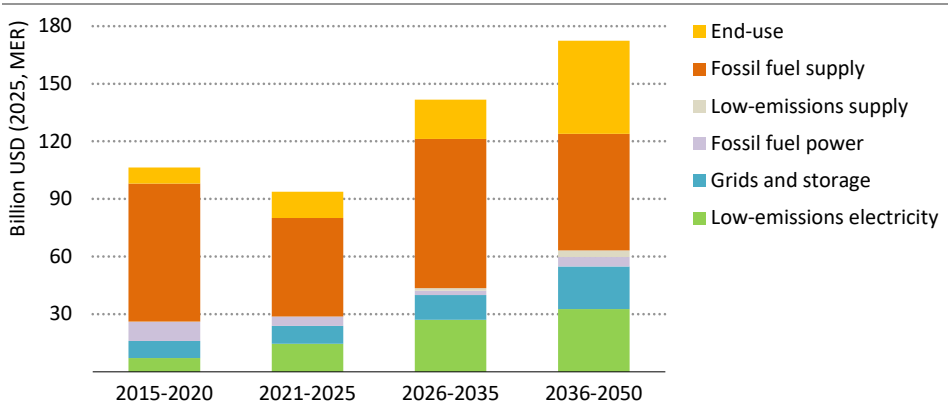
for around two-thirds of output today – towards sub-Saharan Africa, whose share overtakes North Africa's right after 2035. While oil production falls, Africa's refining capacity is due to increase on the back of efforts to lessen dependence on imported oil products. The Dangote refinery, with a capacity of 700 kb/d, has helped reduce import dependence amid the 2026 energy crisis, despite lingering regulatory and operational difficulties, while also providing a lifeline for Europe's jet fuel supply.

Even though it is home to one-fifth of the world's population, Africa accounts for only 3% of global energy investment. While annual energy investment in Africa is set to rise by 11% in 2026 to around USD 110 billion, this level remains well below what is needed to deliver Africa's energy access and growth ambitions. Spending remains skewed towards fossil fuel supply and export-oriented infrastructure rather than domestic power systems, grids and clean energy deployment (Figure 8.20). Upstream investment is concentrated in a handful of established producers, although emerging suppliers such as Mozambique, Namibia, Senegal and Uganda are attracting greater capital, much of it for projects geared towards exports.

Figure 8.20 ▷ Average annual energy investment by type in Africa in the STEPS, 2015-2050



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Energy investment in Africa remains low relative to the continent's needs, but it is expected to rise steadily and to become less focused on fossil fuels

The solar boom in Africa: beyond utility scale

Rising solar PV imports are reshaping the energy landscape in Africa. Since 2017, solar PV imports to Africa have surged, with most of the increase coming from China, where imports have grown 28-fold (see Chapter 1, Box 1.9). These imports have helped drive an eightfold increase in installed solar capacity over the same period, with South Africa alone accounting for more than one-third of total additions. In the STEPS, installed capacity is projected to increase sixfold from its current level in the next decade. Growth to date has supported a large pipeline of utility-scale projects across the continent, including installations serving

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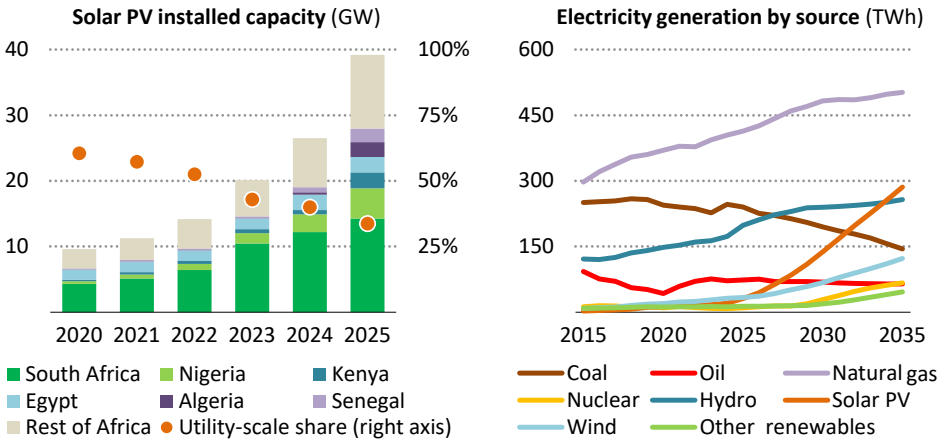
industrial consumers, electrolytic hydrogen developments in North Africa (Box 8.2), and major mining operations, notably in the Democratic Republic of the Congo, where Africa's first 24/7 solar-powered baseload mining project has been commissioned. However, small-scale solar has emerged as the major driver of solar PV capacity growth in 2025. A decade ago, PV capacity was almost exclusively devoted to utility-scale projects in more mature markets such as Egypt and South Africa. Today, sales of small systems are booming, with Algeria, Kenya, Nigeria and Senegal each adding over 1 GW of capacity in 2025 (Figure 8.21).

Figure 8.21 ▷ Solar PV installed capacity and utility-scale share of solar, and electricity generation by source in Africa in the STEPS, 2015-2035



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The solar boom is contributing to the decline of coal and oil-based power generation across Africa, with natural gas increasingly providing flexibility to the system

Note: Other renewables include concentrating solar power, geothermal and modern bioenergy.

Much of the projected solar PV growth to 2035 is expected to serve rising electricity demand from existing users rather than connect new users without access to electricity. Many small solar systems are being bought to provide backup power or supplement existing domestic solar systems, the vast majority of which are below 10 watt-peak and can support little more than lighting and phone charging. Targeted efforts can build on this foundation to extend higher levels of electricity access and ensure that the solar boom contributes to progress towards universal access.

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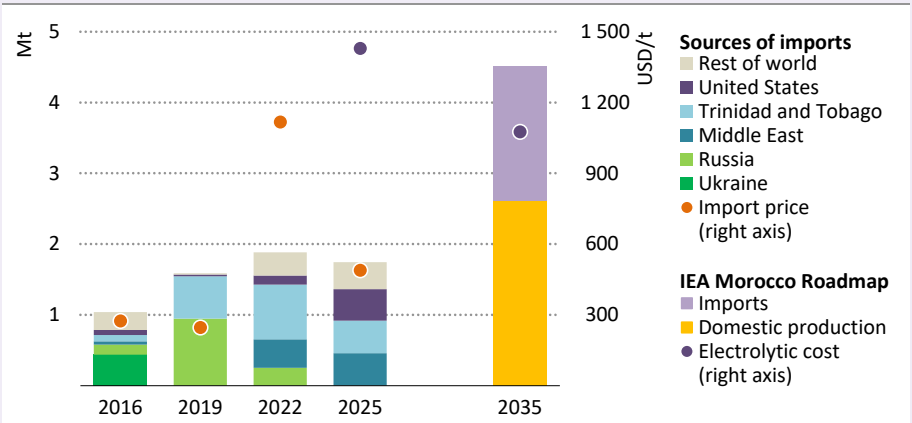
Box 8.2 ▷ Can Morocco unlock its hydrogen potential?

Morocco has ambitions to make use of its vast wind and solar resources to become a major producer of hydrogen-based fuels. It plans to export some to Europe while consuming the rest domestically in its growing fertiliser industry. Morocco is home to the world's largest phosphate reserves and supplies 10% of global phosphate-based fertilisers. Fertiliser production requires ammonia, which is largely made today from natural gas, but it can also be made using hydrogen. Morocco is currently one of the world's largest importers of ammonia and has been exposed to price spikes brought about by energy supply shocks. In 2022, the average ammonia import price shot up to above USD 1 000 per tonne, narrowing the gap with the cost of ammonia production using electrolytic hydrogen in Morocco (Figure 8.22).

Domestic production of ammonia using electrolytic hydrogen could reduce Morocco's exposure to volatile import prices, but the economics remain challenging. While Morocco's renewable resources can provide low-cost electricity, around three-quarters of production costs are attributable to electrolysers, ammonia synthesis equipment and financing. Lower-cost financing and firm long-term offtake agreements will be needed to attract the necessary level of new investment. Other countries in Africa, including Egypt and Namibia, are also exploring the possibility of becoming major hydrogen producers. Countries with high energy demand for fertilisers, refining and heavy industry could produce hydrogen to reduce reliance on imports, but in the near term, they are likely to face investment and market development challenges similar to Morocco's.

Figure 8.22 ▷ Ammonia imports and electrolytic costs in Morocco, 2016-2035



Domestic ammonia production could reduce Morocco's exposure to volatile imports

Notes: USD/t = US dollars per tonne. The IEA Morocco Roadmap, explored in more detail in a forthcoming IEA special report, outlines a pathway towards Morocco's long-term goals.

Source: IEA analysis based on Morocco's Foreign Exchange Office (2026).

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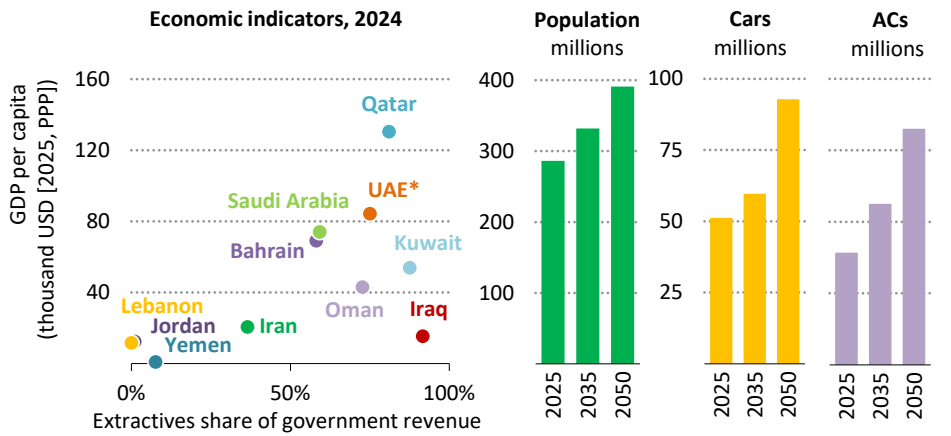
8.6 Middle East

The 2026 conflict in the Middle East will have deep and lasting implications for the region. In addition to being a major producer of oil and natural gas, the region is home to 290 million people and hosts a wide range of industrial sectors (Figure 8.23). The conflict has disrupted not just energy flows but also supply of a wider set of goods and services in the region, ranging from food to transportation. Since governments from producer economies rely on the oil and gas sector for significant shares of their revenues, the conflict will also affect spending and consumption in many countries.

Figure 8.23 ▷ Economic indicators in 2024, and population, cars and residential ACs in the Middle East in the STEPS, 2025-2050



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Countries in the Middle East have varying levels of GDP and government revenues from extractive sectors; the region's population and consumption of goods are both growing

*Data for the United Arab Emirates (UAE) is for 2023.

Note: PPP = purchasing power parity; AC = air conditioner.

Sources: IEA analysis based on IMF's World Revenue Longitudinal Database (WoRLD) (2026); World Bank DataBank (2026).

The conflict may have shaken confidence, but the gradual de-escalation of hostilities assumed in all scenarios leads the underlying drivers of energy development in the Middle East to reassert themselves. The region adds around 45 million people to its population over the next decade in the STEPS, together with over 8 million cars and around 17 million air conditioners. Built space grows by over 20% in this period, while industrial energy demand rises by 15%, alongside an average annual GDP growth rate of more than 3% across the region. As a result, in the STEPS, energy demand grows by 15% to reach 43 exajoules (EJ) by 2035 (Figure 8.24).

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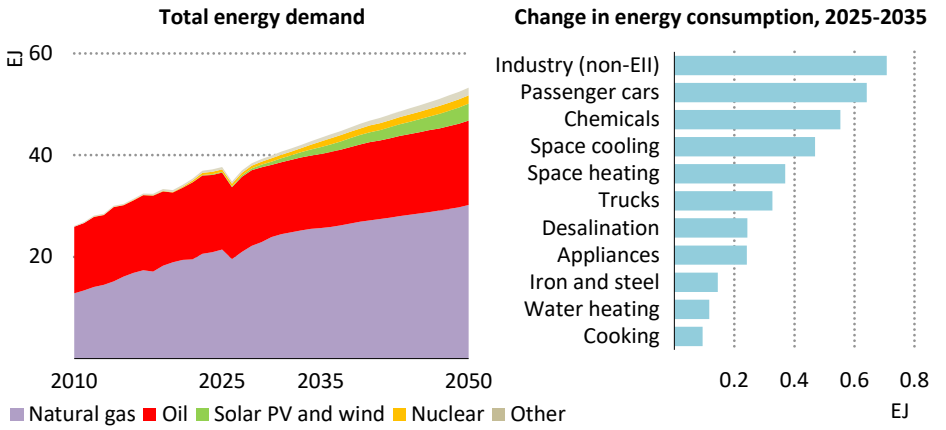
Growing energy demand is evident across all sectors from 2025 to 2035 in the STEPS. Overall industrial activity – including non-energy-intensive industry, chemicals and iron and steel – grows by 20% over the decade. Industry accounts for about 40% of the total throughout the period. Passenger cars account for the largest increase in transport demand, while space cooling leads demand growth in buildings. Overall, 30% of the growth in energy consumption to 2035 is met by electricity in the STEPS, raising the region's rate of electrification to just under 20%, up from 17% today.

Figure 8.24 ▷ Total energy demand by fuel in the STEPS, 2010-2050 and change by sector in the Middle East in the STEPS, 2025-2035



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Overall energy demand increases to over 50 EJ, with large changes reflected in non-energy-intensive industry, transport and thermal comfort

Notes: Non-EII = non-energy-intensive industry. Other includes biomass, coal, hydro, solar thermal and modern bioenergy.

Wind and solar PV are the fastest-growing sources of energy in the region, rising ninefold to 2035 in the STEPS, although from a low base. Together with nuclear, these low-emissions sources meet 10% of energy demand by 2050, up from 2% today. Oil and natural gas continue to dominate the energy mix in the STEPS, between them accounting for nearly 90% of energy demand in 2050. From 2025 to 2035, an average of 31 mb/d are produced in the region in the STEPS, together with 830 bcm per year of natural gas. In total, about 40% is consumed domestically, while the rest is exported. At over 90%, the share of fossil fuels in total energy demand in 2050 in the CPS is only marginally higher than the equivalent figure in the STEPS. However, the way in which countries react to the energy crisis stemming from the conflict in the Middle East will have a profound influence on producers in the region, as explored below.

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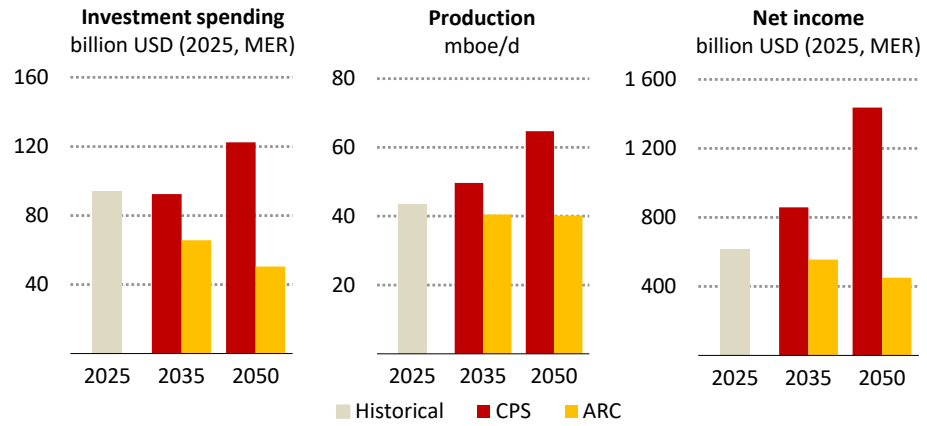
Implications of energy security measures by importers for oil and gas exporters in the Middle East

The contrasts between the CPS and the ARC highlight the strategic uncertainty facing the Middle East (Figure 8.25). In the CPS, importing countries continue to buy oil and natural gas after the 2026 energy crisis very much as before, and producers in the Middle East react to sustained demand for their oil and gas with investment and production, which provides income and fiscal stability. In the ARC, however, persistent energy security risks mean that importing countries give a much higher priority to diversification and import substitution, weakening demand for oil and natural gas from the Middle East.

Figure 8.25 ▷ Oil and natural gas investment, production and net income in the Middle East in the CPS and the ARC, 2025-2050



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The flow of resources from investment to production grows steadily in the CPS, with net income crossing USD 1 trillion between 2035 and 2050

Note: mboe/d = million barrels of oil equivalent per day; CPS = Current Policies Scenario.

In the CPS, investment in oil and natural gas production averages around USD 95 billion to 2035, and it then increases further to an average of USD 110 billion through to 2050, though some of this rising investment reflects cost inflation. As a result of this investment, production increases by over 10% from today's level to 50 mboe/d by 2035, and it then rises further to over 60 mboe/d by 2050.

In the CPS, net income from oil and gas grows from USD 620 billion in 2025 to USD 860 billion in 2035, and it rises to around USD 1.4 trillion by 2050. These revenue streams provide fiscal stability for governments and enable national oil companies to continue to diversify oil and gas value chains internationally – including by investing in upstream projects, LNG, and refining and petrochemicals assets outside the Gulf.

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Exports from the Middle East largely rely on key maritime chokepoints, including the Strait of Hormuz, the Strait of Malacca, the Red Sea, the Bab el-Mandeb Strait and the Suez Canal, with 20% of global traded oil and LNG production flowing through the Strait of Hormuz in 2025. Around 8 mb/d of pipeline capacity that bypasses the Strait of Hormuz is currently available in the Persian Gulf to serve export markets. New capacity under construction is set to expand bypass routes by 1.8 mb/d. Several other projects are under consideration and these could add a further 5 mb/d of capacity to avoid the waterway.

By contrast, the ARC assumes that the crisis has more durable effects on patterns of trade, reflecting the possibility that Middle East exports may not be reliably available to markets and could remain subject to a material risk of disruption. By 2035, global oil and LNG demand are 9% and over 30% lower, respectively, compared with the CPS, and importing countries accelerate efforts to develop sources of supply outside the Gulf. As a result, oil exports from the region are around 20% lower than in the CPS by 2035, and LNG exports are 60% lower.

These challenges translate into much lower investment requirements in oil and gas in the region and lower production and income, creating a more difficult backdrop for governments that have historically relied on fiscal revenue from fuel exports. Investment in oil and natural gas production in the ARC is around 30% lower in 2035 relative to both the 2030 level in the CPS and the 2025 level.

In the ARC, the impacts are not equally distributed among countries. Some producers are less well equipped than others to withstand the headwinds. Iraq, for example, has made limited progress in diversifying its economy, faces challenges in modernising its infrastructure and electricity supply, and relies more on Gulf shipping routes for its crude exports, leaving it more exposed to disruptions than producers with greater flexibility over export routes. By contrast, Saudi Arabia and the United Arab Emirates benefit from low-cost resources and a healthy pipeline of committed investments across the energy value chain.

Even if the risks that chokepoints will interrupt energy supply cause importing countries to seek alternative sources, Middle Eastern oil and gas would still be very difficult for importers to replace entirely, given its low-cost base, scale, quality and established producer-consumer relationships. Lower external demand, or a shift by some buyers towards diversified suppliers and routes, would nevertheless reduce export revenues and fiscal space. This could, in turn, slow the pace of economic diversification and clean energy investment in producer economies. With a growing population, rising cooling demand and expanding industrial activity, more oil and gas may well be consumed within the region.

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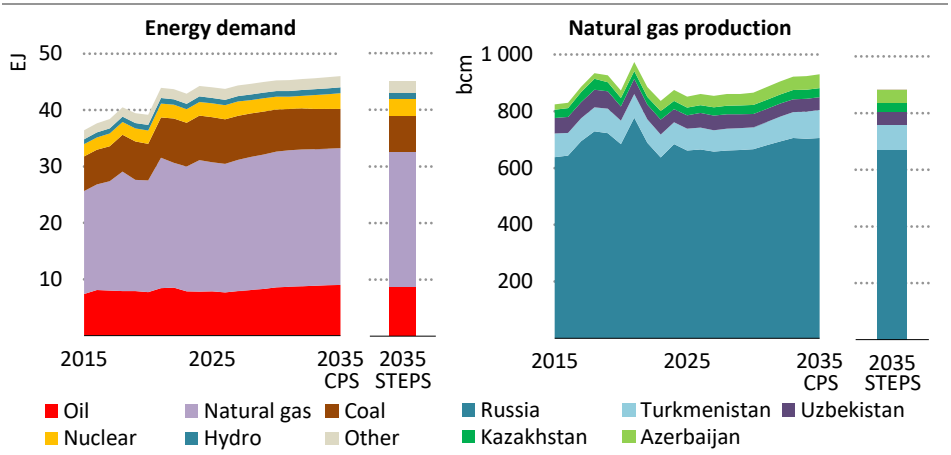
8.7 Eurasia

The countries of the Caspian region and the Russian Federation (referred to here as Eurasia) are heavily reliant on fossil fuels, which accounted for almost 90% of their total energy demand in 2025 – the second-highest regional average after the Middle East (Figure 8.26). Natural gas is the dominant fuel, meeting more than half of the region's energy demand in 2025. Fossil fuel dependence is projected to stay broadly flat over time: renewables deployment rises from a very low base, and additional nuclear capacity comes online, but these changes are offset by the increased use of natural gas. As a result, by 2035, the share of the energy mix covered by fossil fuels declines by 0.5 percentage points in the CPS and 1 percentage point in the STEPS.

Figure 8.26 ▷ Energy demand and natural gas production in Eurasia in the CPS and the STEPS, 2015-2035



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The energy mix in Eurasia remains dominated by natural gas through to 2035, with Russia as the largest producer and limited divergence between scenarios

Note: Other includes other renewables, traditional use of biomass and non-renewable waste.

Eurasia is also a major producer and exporter of fossil fuels, exporting around 200 bcm of natural gas and 9 mb/d of oil in 2025. Russia accounts for more than 75% of the region's oil and gas exports. However, trade flows have been significantly reshaped following Russia's full-scale invasion of Ukraine, in particular by the European Union's phase-out of Russian oil, gas and coal imports, and by Ukrainian strikes on Russian oil infrastructure in 2026, which have led to a 1.5 mb/d decline in oil product exports. In the CPS, natural gas production in Eurasia grows by 80 bcm by 2035, reflecting both rising exports and growing demand within the Caspian region. The largest increase comes from Russia, followed by Turkmenistan, where output expands by one-third as the development of the giant Galkynysh field

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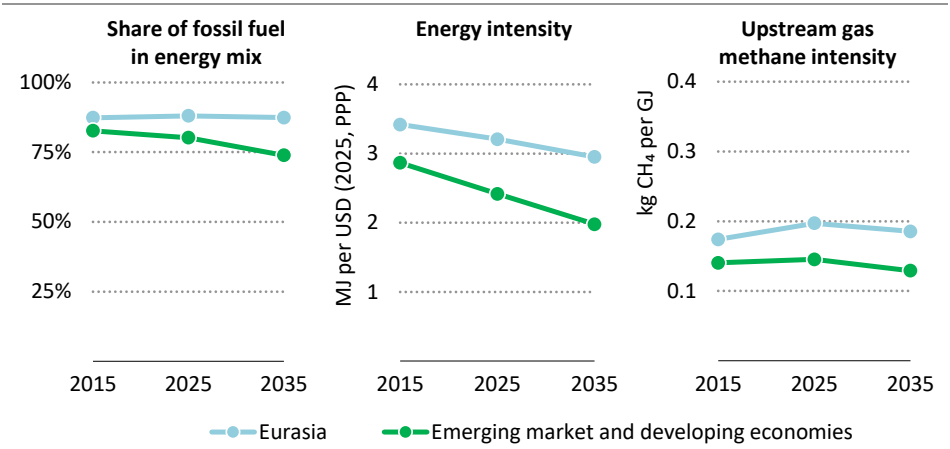
advances. In the CPS, Russia manages to offset some of the export volumes lost to Europe by commissioning the 50 bcm Power of Siberia 2 pipeline to China in the mid-2030s. The pipeline is assumed to ramp up to full capacity by 2040.

At around 3.2 megajoules (MJ) per USD of GDP, Eurasia's energy intensity is 30% higher than the average for other emerging market and developing economies (Figure 8.27). This reflects multiple factors: a cold climate, an energy-intensive industrial base, ageing infrastructure and persistent inefficiencies in energy supply and use. Widespread fossil fuel subsidies that keep energy prices low discourage efficiency improvements and reinforce the dominance of fossil fuels in the energy mix.

Figure 8.27 ▷ Selected indicators in Eurasia in the CPS, 2015-2035



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Eurasia relies more on fossil fuels than other EMDE, has higher levels of energy intensity and operates more emissions-intensive oil and gas production; the gaps widen in the CPS

Notes: GJ = gigajoule; MJ = megajoule; kg CH_4 = kilogrammes of methane; EMDE = emerging market and developing economies. Energy intensity is shown as total final consumption divided by GDP.

Gas production in Eurasia is 40% more methane emissions-intensive than the average among emerging market and developing economies. Ageing infrastructure and inadequate maintenance at production sites contribute to these high emissions levels. Among the region's producers, Turkmenistan ranks among the most methane emissions-intensive gas producers worldwide, and Uzbekistan is also high on the list. In the CPS, upstream gas methane intensities in Eurasia decline by 5% by 2035, compared with reductions of around 10% across emerging market and developing economies as a whole. Deploying readily available methane abatement measures could reduce regional fossil fuel methane emissions by almost 70%, with the largest reductions concentrated in Russia's oil and gas sector. Nearly half of these reductions could be achieved at no net cost to producers, with the value of captured gas offsetting the cost of abatement.

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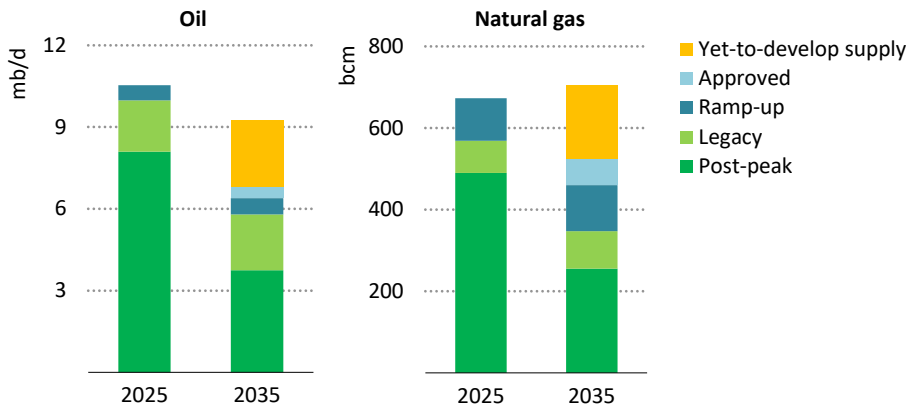
Challenging times for Russia's oil and gas sector

Around 75% of current Russian oil and gas production comes from mature, conventional fields that have passed peak production (Figure 8.28). A further 15% comes from legacy oil and gas fields that were brought online before 2015 and have yet to reach peak production. The remaining 10% comes from newer projects that are still ramping up. The production levels in the CPS in 2035, which are not far off today's, assume that Russia approves and develops around 2 mb/d of new oil supply and 180 bcm of new gas supply beyond the anticipated production increase from projects that have already been approved. This new supply includes extensions to existing projects and the exploitation of discovered and appraised resources that have yet to be approved for development.

Figure 8.28 ▷ Oil and natural gas supply in Russia in the CPS, 2025-2035



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In the CPS, Russia approves and develops around 2 mb/d of new oil supply and 180 bcm of new gas supply by 2035

Meeting this need for new supply means developing more expensive resources and deploying enhanced recovery techniques in the country's traditional oil provinces in western Siberia. It also means developing greenfield resources in the Arctic, eastern Siberian and offshore regions, where substantial technological and infrastructure requirements make the economic case for projects challenging. However, sanctions, the near-term prioritisation of the war economy over the energy industry, and geopolitical tensions have increased development risks, restricting access to technologies, service providers and sources of finance.

These upstream challenges come at a time when Russia's hydrocarbon revenues face major headwinds. Oil and gas export revenues in 2025 were around 30% lower than in 2021; despite a rebound in 2026 supported by higher oil prices and the temporary waiver granted for seaborne Russian oil exports, revenues are expected to trend lower again. In the CPS, net

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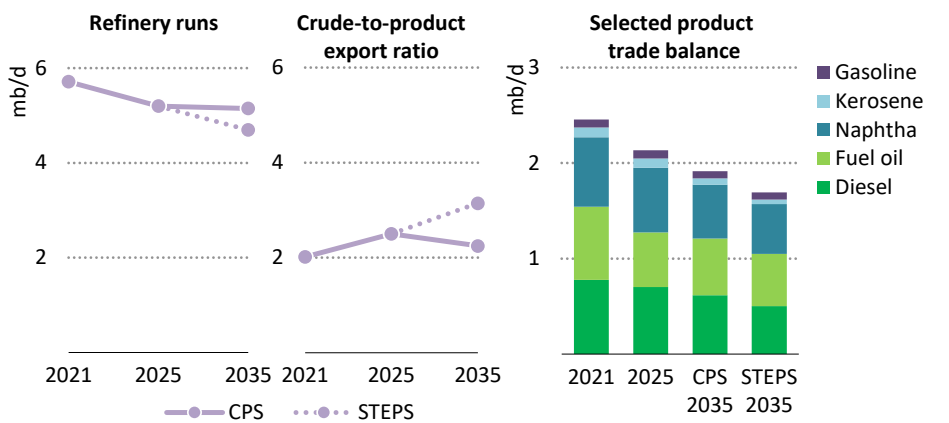
export revenues from oil and gas are around USD 160 billion by 2035, which is 30% below average levels between 2021 and 2025. In the STEPS – which sees lower demand for imported fuels – revenues fall 50% below 2021-2025 levels.

Russia's refining industry is also under acute strain. Historically one of the world's largest product exporters, Russia has seen refinery throughput fall since 2021 as sanctions on oil exports and repeated Ukrainian attacks on refining facilities have disrupted operations. Refinery runs fell 10% below pre-war levels to 5.2 mb/d in 2025, and in 2026, they have fallen to 4 mb/d (Figure 8.29). Damage to conversion units has reduced the ability of refineries to maximise gasoline, diesel and jet fuel yields, contributing to domestic gasoline shortages and tighter global diesel markets. As refinery throughput has declined, the share of crude exports has increased, raising the crude-to-product export ratio from 2 in 2021 to 2.5 in 2025.

Figure 8.29 ▷ Refinery runs, crude-to-product export ratio and net product trade balance in Russia in the CPS and the STEPS, 2021-2035



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Refinery runs in 2035 are similar to the 2025 level in the CPS, yet higher domestic demand means oil product exports are down

Note: Crude-to-product export ratio is defined as net crude exports divided by net product exports.

In the CPS, refinery runs recover from the 2026 level to just above 5 mb/d by 2035, which is still well below pre-war levels. Limited investment constrains Russia's ability to modernise its refining sector, exposing it to competition from new export projects. Rising diesel supply from China, India and the Middle East fills the gaps left by Russian exports. By 2035, refinery runs at around 2025 levels and similar crude exports mean the crude-to-product export ratio stays broadly flat. In the STEPS, the constraints are even greater because of weaker global oil demand: refinery runs stand at around 4.7 mb/d by 2035, and the crude-to-product export ratio rises to above 3.

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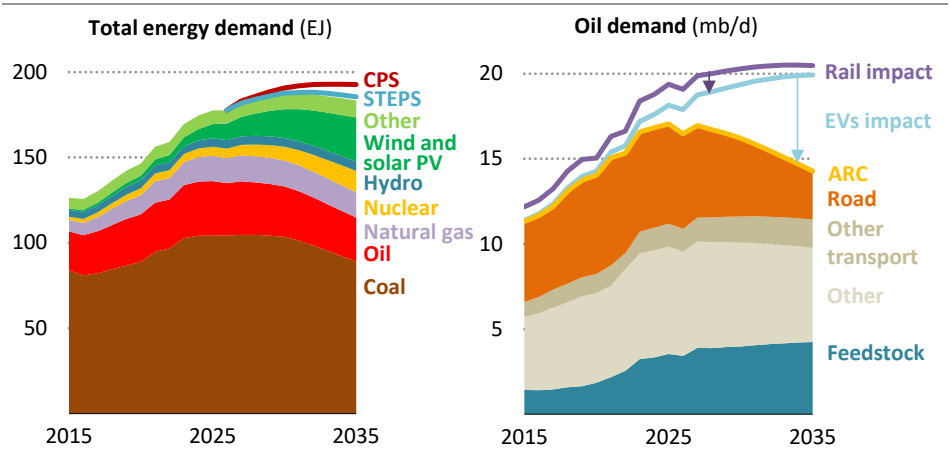
8.8 China

Across all scenarios, China's economy grows on average by 3.5% per year to 2035, compared with an average of 5.5% over the past decade. Recent GDP data point to an increasing reliance on exports to support economic growth, although trade tensions are also rising globally. The slowdown in economic growth reflects weaker consumer demand, subdued investment and a prolonged property downturn, as well as a shrinking working-age population that is expected to constrain labour supply and limit long-term economic expansion. These structural economic and demographic trends increasingly shape the country's energy outlook.

Against this backdrop, China's energy challenge is shifting from expanding its energy system to optimising the one built over the past two-and-a-half decades. This transition is reflected in the 15th Five-Year Plan (2026-2030), which prioritises energy security, electrification, renewable integration, power system flexibility, innovation and wider application of clean energy technologies. The strategy also aims to strengthen domestic clean energy supply chains and improve the resilience and efficiency of the overall energy system.

Figure 8.30 ▷ Energy demand by source and oil demand by sector in China in the ARC, 2015-2035



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Energy demand plateaus and oil demand peaks as the deployment of electric vehicles and rail grows strongly over the coming decade

Notes: Other includes total oil demand excluding transport and chemicals feedstock. The results of the case, excluding the impact of rail and EVs, are calculated against a counterfactual in which mobility needs currently covered by EVs are instead served by conventional powertrains, while non-urban rail activity growth in China since 2000 is instead served by road and aviation transportation.

These structural trends and evolving policy priorities lead to a plateau in China's overall energy demand in all scenarios by 2035. The electrification of transport plays an important

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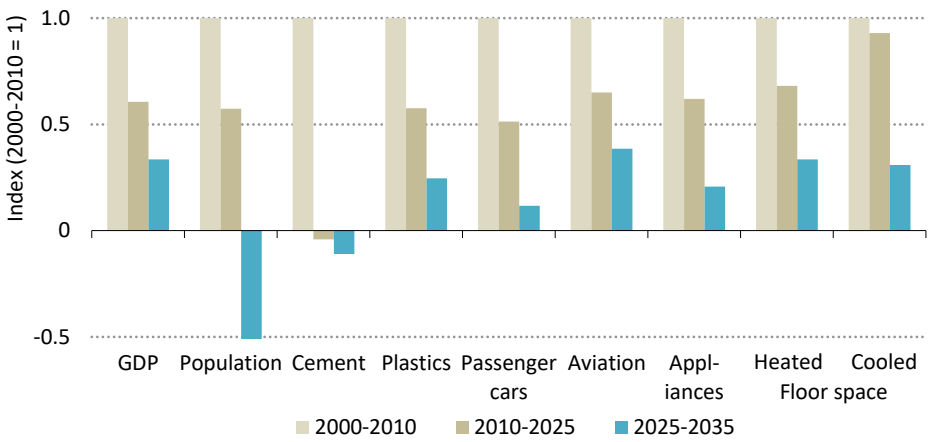
part in this. EVs, alongside the continued expansion of the rail network, have already reduced oil demand by around 2.5 mb/d. This reduction reaches above 6 mb/d by 2035 in the ARC (Figure 8.30). Electric and natural gas-powered trucks now account for more than half of annual heavy freight truck sales. The decline in oil demand resulting from these changes is evident across all scenarios, but it is particularly pronounced in the ARC, which reflects the goal in China's 15th Five-Year Plan to scale up the deployment of "new energy" heavy-duty trucks.

In other sectors, policy priorities increasingly focus on improving efficiency and reducing emissions rather than expanding capacity. In industry, the focus is on electrification and reducing emissions from energy-intensive processes, while in buildings, the emphasis is on smart energy management, greater integration with the power system, and electrification.

Figure 8.31 ▷ Average annual growth in selected demand drivers by time period in China, 2000-2035



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Growth in energy demand drivers is set to slow in the coming years, although a robust rise is still expected for plastics, heating, cooling and aviation

Notes: These demand drivers are largely consistent across all scenarios. Average annual percentage changes are indexed relative to the 2000-2010 period, which is set to 1.

China's population is now declining in the face of low fertility rates and rapid ageing. In industry, steel and cement output has peaked, and future industrial growth is increasingly concentrated in plastics production alongside high-value products from non-energy-intensive industries. In other sectors, the expansion in passenger car and household appliance ownership over the last decade limits further growth in these areas, although demand for aviation is still expanding at a more robust pace (Figure 8.31). These demographic, industrial and consumption trends underpin the outlook and reshape the sectoral composition of final energy consumption.

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How China is reshaping its electricity system through the 15th Five-Year Plan

China's 15th Five-Year Plan, released in March 2026, seeks to meet rapid growth in electricity demand while strengthening energy security and reducing reliance on imported fuels by expanding domestic energy resources, including renewables, nuclear and coal. This marks a new phase of power sector development focused on energy security, technological self-reliance, market reform and faster clean energy deployment. At its core is an integrated power system with expanded grids, greater system flexibility, more renewables and a new emphasis on the role of coal in supporting reliability and security.

China is already one of the most electrified economies in the world, reaching an electrification rate of 32% in 2025. In the STEPS, this rate is projected to rise to close to 45% in one decade as China continues to electrify transport, industry and buildings while expanding its digital infrastructure and supporting the rapid growth of data centres. By 2035, electricity demand in the STEPS is projected to be around 4 400 TWh higher than in 2025. The industrial sector accounts for one-third of this increase, while appliances and cooling contribute a further nearly 25%. Road transport is responsible for over 15% of the additional demand as the market share of electric cars in new sales rises from around 55% today to over 90% by 2035 in the STEPS. Most of the remaining 25% of demand growth comes from data centres. Low-emissions hydrogen production reaches nearly 3.5 million tonnes (Mt) by 2035, supported by China's 15th Five-Year Plan.

Rapid electricity demand growth in China no longer implies increasing coal use. Coal is seen as a key source of capacity adequacy and flexibility in a system increasingly driven by renewables and nuclear power. Although coal-fired capacity is projected in the STEPS to increase by one-third between 2025 and 2035, lower average utilisation means that total electricity generation from coal-fired plants is projected to peak before 2030 and fall below today's level by 2035. This marks a clear break from the coal-led growth pattern of the past two decades. Natural gas-fired power capacity is also set to expand to ensure adequate supply – though here, too, relatively low utilisation rates moderate the related increase in electricity generation.

Although renewables are projected to provide the largest share of additional electricity generation over the next decade in the STEPS, the integration of variable renewables into the power system is becoming increasingly challenging. Output from hydropower, the largest renewable source of electricity today, is projected to expand by about 10% to 2035, largely due to progress on the Yarlung Zangbo hydropower project, which is set to be the largest in the world when completed. For existing hydropower projects, annual generation can vary significantly with hydrological conditions; in recent years, hydro output has deviated by up to 30% from typical levels during drought periods. Output from variable renewables is also posing challenges; curtailment of solar PV and wind was largely under control in the early 2020s at around 2% to 3% annually, but it rose to about 4% in 2024, around 6% in the first half of 2025 and nearly 9% in the first two months of 2026.

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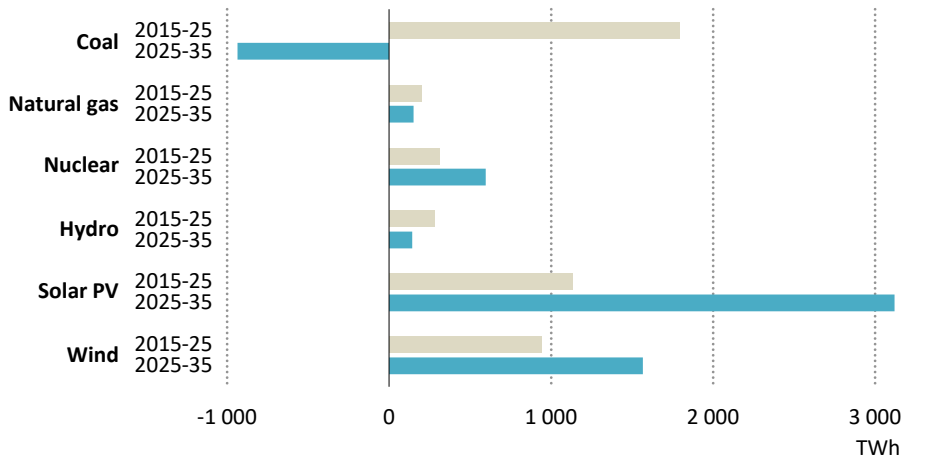
In response to mounting integration challenges, China accelerated power market reforms in 2025 by moving new wind and solar PV projects from tariffs set administratively towards market-based pricing and competitive auctions. Meanwhile, the return on capital invested in manufacturing has dropped below zero for solar modules, while holding steady for wind turbines (IEA, 2026d). Together, these trends are reshaping the composition of renewable growth. Following the introduction of China's power market reforms, solar PV capacity additions in the second half of 2025 fell by around 50% compared with the same period the previous year, while wind additions increased by about 20%. Deployment data from the first half of 2026 indicate that solar PV additions are further slowing, while wind additions are increasing.

After broadly similar increases in wind and solar PV generation over the past decade, their trajectories diverge in the STEPS, as continued rapid growth in China's solar PV market sees solar generation substantially outpace wind through 2035 (Figure 8.32). The total increase in wind and solar PV generation over the next decade is set to more than double the rise in the previous one, reflecting both the recent resurgence of wind deployment and a growing recognition that a diversified renewable portfolio provides important system benefits.

Figure 8.32 ▷ Change in electricity generation by source in China in the STEPS, 2015-2035



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To meet electricity demand growth of about 4 400 TWh to 2035, China's 15th Five-Year Plan sets the course to rely heavily on renewables and nuclear, plus coal for flexibility

Nuclear power also plays an important part in this transformation. China already hosts the world's largest reactor construction programmes, accounting for more than 40% of all nuclear capacity under construction globally today. In the STEPS to 2035, nuclear generation is set to expand by twice as much as seen in the previous decade. This acceleration reflects

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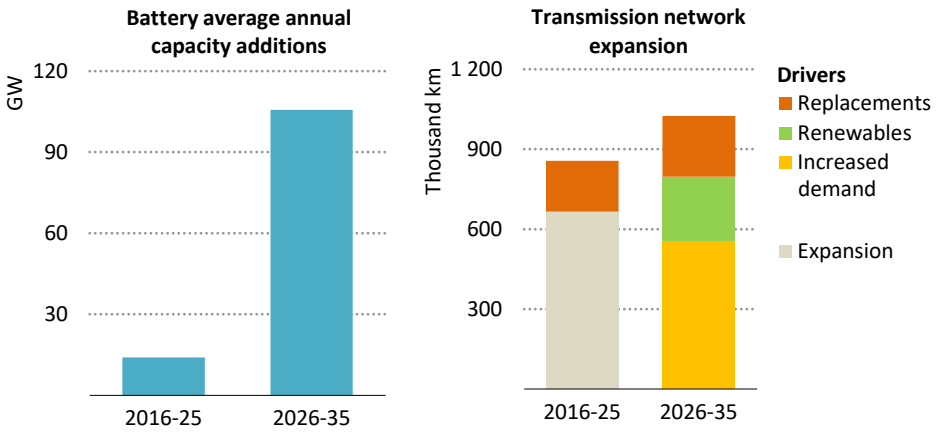
the importance of firm, low-emissions electricity in diversifying supply and supporting long-term energy security within a system in which variable wind and solar sources provide an increasing share of power. China is projected to overtake both the European Union and the United States in nuclear capacity in operation by around 2030.

Figure 8.33 ▻ Average annual battery capacity additions and total transmission network expansion in China in the STEPS, 2016-2035



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To ensure electricity security in its changing power system, China is poised to accelerate transmission grid expansion and deployment of batteries and other energy storage

Notes: km = kilometre. Historical replacements for transmission network infrastructure are estimated based on assessments of ageing assets and typical equipment lifetimes.

China's power transformation will depend as much on infrastructure as on new generation. In the STEPS, battery storage additions over the next decade are projected to be almost eight times higher than over the previous one, while transmission grids are set to expand by 40% by 2035 (Figure 8.33). Additional ultra-high-voltage and high-voltage direct current transmission is planned to help move renewable electricity from resource-rich regions in the north and west to demand centres in the south and east. Well over 400 000 kilometres (km) of new distribution lines are set to be added each year to 2035 to serve new demand. Together, storage and grids will be central to maintaining electricity security while facilitating a much larger role for renewables and nuclear power.

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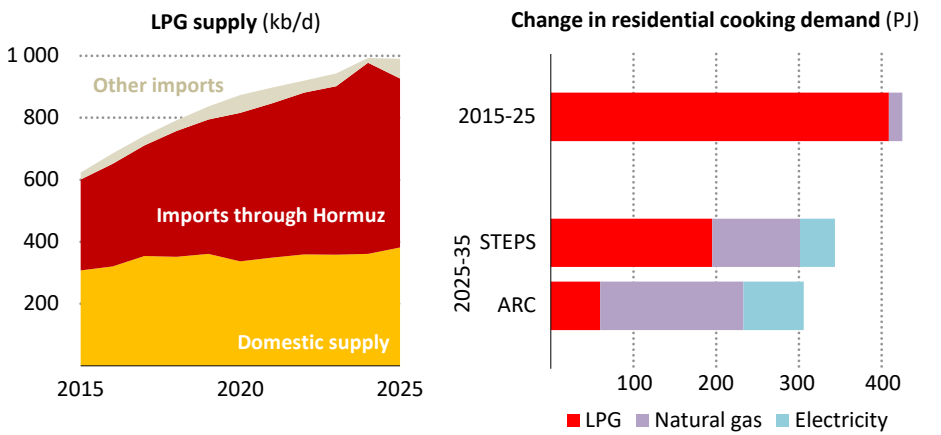
8.9 India

India imports around 40% of its energy demand, including 90% of its crude oil and 50% of its natural gas. The 2026 conflict in the Middle East has caused particular disruption to the supply of primary cooking fuel: the liquefied petroleum gas (LPG) in half of the cylinders used in residential cooking in India transits through the Strait of Hormuz (Figure 8.34). LPG imports fell by over 50% during the first two months of the conflict. The government responded by maximising domestic LPG output and prioritising the supply of LPG to households over other consumers. India has been diversifying its cooking energy demand through an ambitious scaling up of natural gas pipelines in urban areas, which now serve over 17 million households. However, the Strait of Hormuz remains critical to India's energy security, even though the expansion of natural gas and electric cooking helps moderate growth in LPG demand over the next decade.

Figure 8.34 ▷ LPG supply and change in residential cooking energy demand in India in the STEPS and the ARC, 2015-2035



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LPG in half of the cylinders used in residential cooking in India transits through the Strait of Hormuz; growing natural gas and electric cooking displaces LPG demand growth

Note: kb/d = thousand barrels per day; PJ = petajoule; LPG = liquefied petroleum gas.

India's energy needs across sectors have been growing fast, and they are on course to continue expanding rapidly. In all our scenarios, India accounts for more growth in energy demand over the next decade than any other country or region in the world. The country is set to add over 12 000 cars to its roads every day over the next decade and to see a 33% rise in built spaces, an additional 200 million air conditioners installed in its homes, and a surge in the production of iron, steel and cement. As a result, energy demand grows by 2.5% annually to 2035 in the STEPS, triple the global rate (Figure 8.35).

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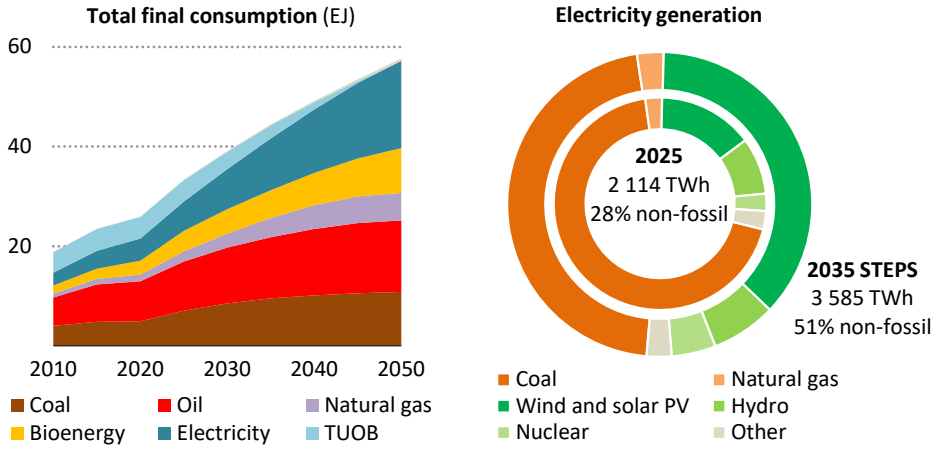
Figure 8.35 ▷ Total final consumption and electricity generation in India in the STEPS, 2010-2050



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The share of electricity in India's energy consumption steadily rises, and over half of power generation comes from renewables and nuclear by 2035

Note: Non-fossil represents the share of generation from renewables and nuclear.

One notable feature of India's evolving energy landscape is the rising electrification of end-uses: the share of electricity in final energy consumption triples between 2000 and 2050. Electricity demand grows by 6% annually over the next decade and continues to increase strongly thereafter. This rapid electrification is being accompanied by an increase in the share of low-emissions sources in the generation mix. Solar PV provided half of India's capacity additions over the past decade, and in 2025, India met its target for half of installed power capacity to be non-fossil five years sooner than planned. As a result, around one-quarter of generation in India was from such sources in 2025. As non-fossil capacity continues to expand, India generates well over half of its electricity from non-fossil sources by 2035 in the STEPS. With plentiful domestic reserves, coal remains a mainstay in India's energy supply, although its role evolves to provide much-needed flexibility to the system. India's emissions growth over the next decade in the STEPS is the largest of all countries and regions, but its per capita emissions remain substantially lower than the global average through the outlook period.

India's pursuit of energy efficiency, electrification and low-emissions energy sources reduces its reliance on imported fuels faster in the ARC than in the STEPS. In the ARC, electric cars are adopted 30% faster than in the STEPS by 2035, and electrification and energy efficiency in industry both accelerate, as does the use of renewables and domestically produced coal in power generation. As a result, India reduces its need for oil relative to the STEPS by 580 kb/d by 2035 and cuts its use of natural gas compared with the STEPS by 8% over the same period. This moves India closer to its stated ambition of "energy independence by 2047".

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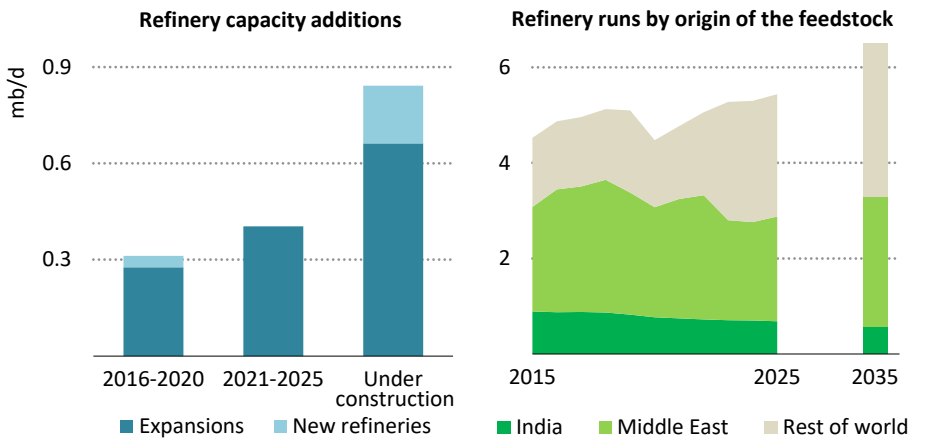
The outlook for India's oil refining sector

India had nearly 6 mb/d of refining capacity in 2025, ranking fourth globally by capacity and third by refinery runs. It imports most of the oil it uses for refining, supporting its position as the world's second-largest net crude importer after China. Although it consumes 5.7 mb/d of oil products domestically, the scale of its refining operations makes the country a net exporter of oil products. With 840 kb/d of refining capacity under construction (660 kb/d of expansion at existing sites and 180 kb/d of greenfield construction), India is poised to further strengthen its role as a supplier of light and middle distillates to global markets (Figure 8.36).

Figure 8.36 ▷ Refinery capacity additions and runs by origin of the feedstock in India in the STEPS, 2015-2035



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With more than 800 kb/d of refining capacity under construction, India is set to increase crude imports, largely from suppliers outside the Middle East

Note: Feedstock includes crude, condensate and diluent.

In 2025, India imported around half of its refinery intake from the Middle East. In recent years, it has also become a major buyer of discounted Russian crude. Imports from Venezuela have increased in 2026, supported by the ability of complex refineries such as the Jamnagar refinery to process extra-heavy crude. In the STEPS, refinery capacity expands by 1 mb/d, while domestic crude production falls by nearly 20% by 2035, leading to a growing reliance on imported supply. India's crude oil imports from the Middle East remain broadly flat to 2035, while total imports grow.

In the STEPS, economic drivers add 0.6 mb/d to demand for diesel, jet fuel and naphtha by 2035. On the other hand, natural gas, EVs and biofuels moderate gasoline demand growth, limiting it to 0.2 mb/d over the next decade, compared with 0.4 mb/d between 2015 and 2025 (Figure 8.37). Refinery yields remain concentrated in diesel and gasoline (60% of total

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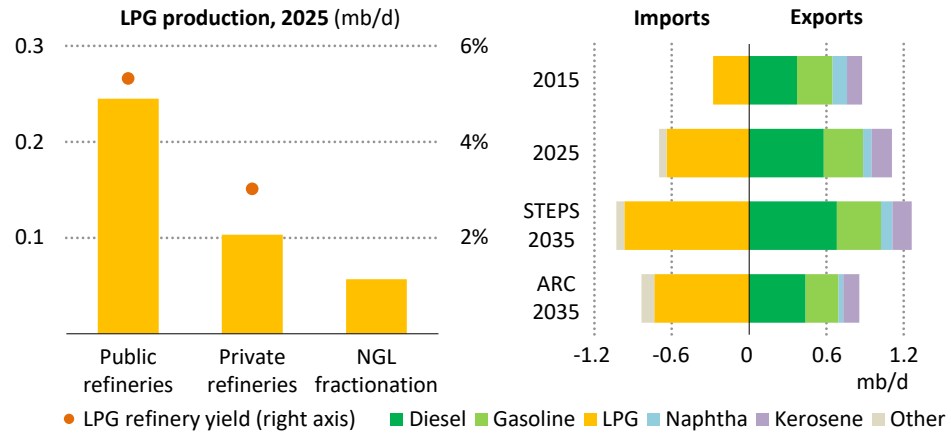
refinery output), supporting exports of light and middle distillates, while the existing structural LPG deficit widens as demand outpaces supply.

Figure 8.37 ▷ LPG production in 2025, and oil product trade balance in India in the STEPS and the ARC, 2015, 2025 and 2035



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Demand for LPG increases faster than output in the STEPS, and India's LPG imports grow by 0.3 mb/d to almost 1 mb/d by 2035, 25% higher than in the ARC

Note: NGL = natural gas liquids.

Source: IEA analysis based on Indian Petroleum & Natural Gas Statistics 2024-2025 (2025).

India is the world's second-largest LPG importer. Domestic production was around 450 kb/d in 2025 and met around 40% of demand, with 15% of the LPG coming from natural gas liquid (NGL) fractionation and 85% from refineries. In the STEPS, supply rises by less than 100 kb/d by 2035, while demand grows by almost 400 kb/d. This gap pushes LPG imports to nearly 1 mb/d. In the ARC, faster uptake of natural gas and electric cooking, combined with higher levels of domestic LPG production, reduces imports in 2035 to below 750 kb/d. With additional domestic supply from NGL fractionation constrained by natural gas production, almost all growth in supply in the ARC comes from refineries. The scope for higher LPG yields was demonstrated in March 2026, when refiners increased output by 180 kb/d following a government directive. Private refineries, where LPG yields are around 40% lower than at public-sector facilities, have bandwidth to increase yields. However, increasing LPG yields comes at the expense of higher-value refinery products, such as diesel and gasoline, which trade at up to two times the price of LPG per barrel; this creates a trade-off between increasing export revenue and reducing import dependence.

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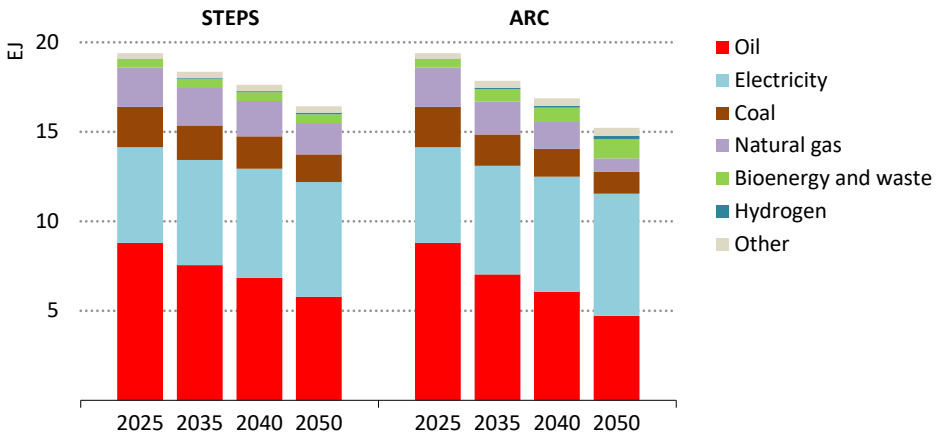
8.10 Japan and Korea

With net imports covering around 80% of their energy demand in 2025, Japan and Korea are among the world's most energy import-dependent economies. This structural reliance on imported fuels has made energy security a central consideration in their national energy policies. Both operate large refining sectors that are highly dependent on imported crude oil, leaving their energy systems exposed to disruptions in global oil supply. They are largely reliant on a limited number of suppliers, with Australia, the Middle East and North America together accounting for more than 60% of their oil, natural gas and coal imports.

The recent disruption to shipping through the Strait of Hormuz highlighted this dependence. In the 2026 energy crisis, both Japan and Korea released oil from their strategic petroleum reserves as part of the IEA's collective action; Japan also expanded fuel subsidies to limit the effect of higher crude prices on consumers, while Korea introduced temporary wholesale price caps for oil products. Although emergency measures have cushioned the immediate impact of higher fuel prices, reducing exposure over the longer term requires a broad shift away from reliance on imported fuels and a small number of suppliers.

Figure 8.38 ▷ Total final consumption by source in Japan and Korea in the STEPS and the ARC, 2025-2050



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Total final consumption declines by about 15% by 2050 in the STEPS and by about 20% in the ARC, led by a reduction in oil demand

Notes: Hydrogen includes hydrogen and H_2-based fuels. Other includes district heat, geothermal and solar thermal.

In addition to short-term responses, both countries are pursuing a range of measures to strengthen energy security in the longer term, including efforts to further diversify sources and routes of fuel supply, boost electrification, improve energy efficiency, expand nuclear

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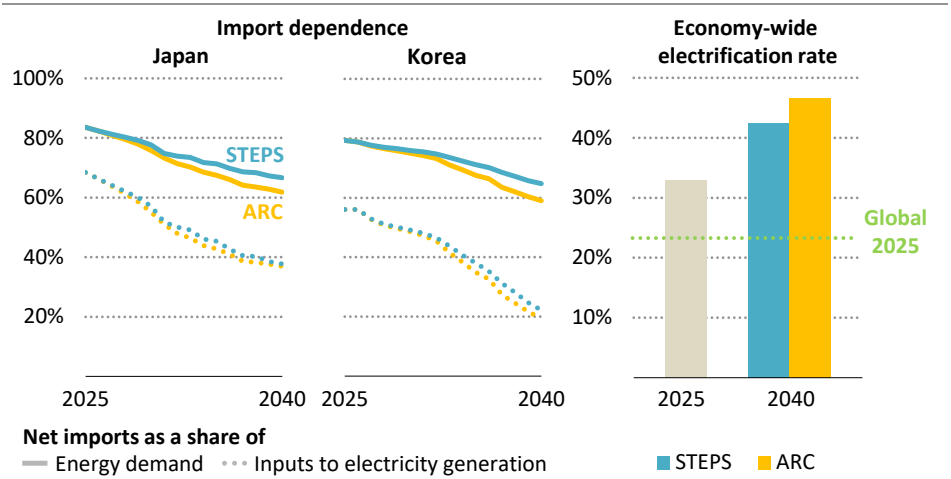
power and deploy domestic sources of electricity. The ARC illustrates one possible outcome of faster implementation of these measures. In this case, total final energy consumption in the region declines by around 20% by 2050, compared with around 15% in the STEPS. Faster electrification and the expansion of domestic low-emissions electricity sources also reduce dependence on energy imports (Figure 8.38).

Accelerated electrification is a feature of the ARC in both Japan and Korea. Electricity demand from transport grows slightly faster in the ARC than in the STEPS, rising nearly threefold from today's levels by 2035. This transition reflects policies already being pursued, plus additional measures implemented in the ARC. For example, Korea has announced a target for electric and hydrogen vehicles to account for 50% of new car sales by 2030, while Japan continues to support vehicle electrification through clean vehicle subsidies and the deployment of charging infrastructure. In addition, Japan has decided that all new passenger vehicle sales should be electrified by 2035, with electrified vehicles encompassing hybrids, plug-in hybrids and fuel cell vehicles. The ARC also leads to further electrification of the buildings and industry sectors at a faster pace than in the STEPS.

As a result, the share of electricity in total final energy consumption for Japan and Korea combined grows more rapidly in the ARC, rising from over 30% today to over 45% by 2040, compared with slightly over 40% in the STEPS (Figure 8.39). This reduces dependence on imported oil and natural gas. The ARC also sees greater diversification of oil, natural gas and coal supplies in both countries.

Figure 8.39 ▷ Net import share and economy-wide electrification rate in Japan and Korea in the STEPS and the ARC, 2025-2040



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Expanding domestic electricity supply enables greater electrification, contributing to lower import dependence, especially in the ARC

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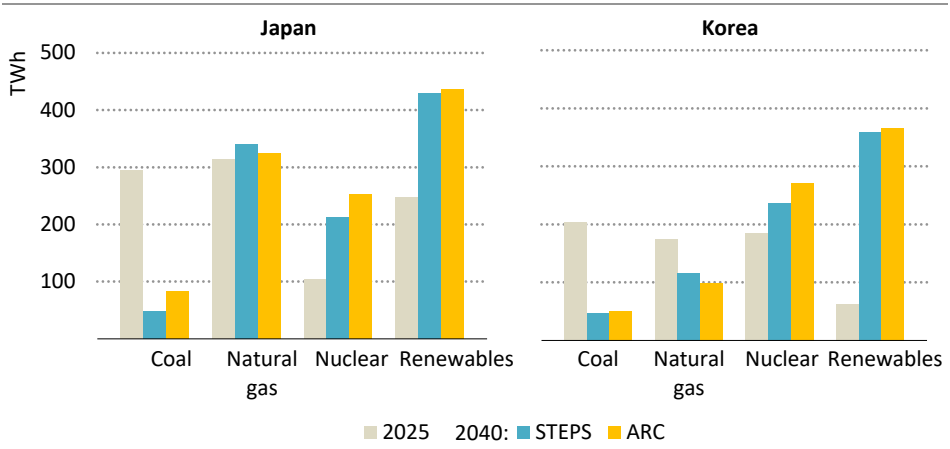
Higher electricity demand in the ARC is met primarily through higher generation from nuclear and renewables, with a slower decline in coal-fired generation. The increase in output from nuclear and renewables is more pronounced than in the STEPS, reflecting faster electrification and a preference for domestically available electricity sources. Gas-fired plants remain important for flexibility and reliability in the power system. The contribution of coal-fired power declines more slowly than the 80% reduction seen in the STEPS, reflecting the relatively diverse range of coal exporters in a case in which energy security considerations are very prominent.

In the STEPS, Japan sees a large increase in nuclear generation, which rises from about 100 TWh today to about 210 TWh in 2040, with its share of overall generation reaching 20%, up from 10% today (Figure 8.40). Renewables also expand substantially, with solar PV generation rising from 110 TWh to around 210 TWh, and wind output increasing from a low base. The scale and pace of expansion are limited by Japan's resource geography and land-use constraints, as well as by the extent of local acceptance and the challenge of integrating more dispersed renewable resources into the power system. Gas generation remains around today's levels and plays an important role in flexibility and reliability. The constraints on renewables deployment explain why Japan's reduction in import dependence is relatively gradual in the STEPS, even as electrification and low-emissions electricity expand.

Figure 8.40 ▷ Electricity generation by source in Japan and Korea in the STEPS and the ARC, 2025 and 2040



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In the ARC, Japan and Korea rely more on low-emissions electricity sources, while gas shifts from a source of bulk generation towards a role in providing flexibility and reliability

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Additional power generation in Korea in the STEPS also comes from growth in renewable and nuclear sources. Renewables expand rapidly, with solar remaining the largest contributor and wind rising sharply from less than 5 TWh to over 130 TWh in 2040. Korea's May 2026 renewable energy plan aims for 100 GW of renewable electricity capacity by 2030 and at least a 30% share of renewables in electricity generation by 2035. It also leaves open the possibility of more ambitious targets for 2040 in the light of rapidly growing electricity demand from semiconductors, data centres and broader electrification. Nuclear generation rises from 185 TWh today to over 230 TWh by 2040, maintaining its share at around 30%. Meanwhile, gas generation falls from 175 TWh to less than 120 TWh by 2040.

As electricity grows increasingly central to final energy consumption, maintaining reliable power systems becomes more critical. Secure power systems require not only sufficient generation capacity but also adequate sources of flexibility, with robust grids, storage and demand-side response all playing important roles in integrating rising shares of variable renewables. Recent policy developments have focused on strengthening grid codes, system operation and technical standards to maintain system stability and reliability. Dispatchable capacity, including gas-fired plants, also provides flexibility and resilience during periods of system stress.

Delivery challenges differ between the two countries. Japan's pathway depends heavily on the pace of nuclear restarts and the extent of nuclear lifetime extensions, as well as timely transmission and grid upgrades to connect renewable resources concentrated far from major demand centres. Korea's pathway combines sustained nuclear output with a faster buildout of renewables, especially offshore wind, requiring additional transmission infrastructure, reforms to system operations, and expanded battery storage and pumped-storage hydropower.

Both these pathways require the parallel delivery of generation, networks and flexibility resources. Nuclear and renewables capacity additions, transmission expansion, grid reinforcement and the provision of flexibility and adequacy services all need to be kept in balance. In both countries, the energy security benefits of electrification depend on whether the infrastructure needed to support it can be delivered in time.

While coal generation declines in both countries in the ARC, thermal capacity continues to play an important role in ensuring electricity security, particularly natural gas-fired plants backed by LNG infrastructure. Gas-fired capacity can provide insurance against periods of low renewable output, unexpected outages, or delays in low-emissions generation and grid projects. As Japan and Korea rely more on nuclear and variable renewables, the role of natural gas shifts away from bulk generation towards providing system flexibility, peak capacity and resilience.

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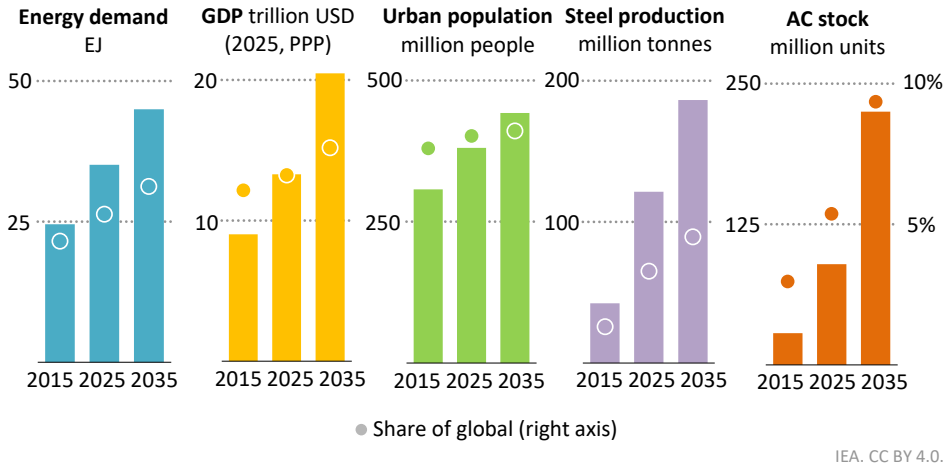
8.11 Southeast Asia

Southeast Asia is the second-largest source of energy demand growth after India in the STEPS, with demand increasing by nearly 10 EJ, or 28%, by 2035 (Figure 8.41). While the economies of countries in Southeast Asia vary in size and structure, all are set to expand, with regional GDP growing by 4.4% per year to 2035 and GDP per capita rising by 3.8% annually over the same period. Population growth is increasingly concentrated in urban areas, and rising incomes and urbanisation are set to lead to greater appliance and vehicle ownership in all scenarios. Air conditioner ownership today ranges from around 80% of households in Brunei Darussalam and Singapore to around 5% in Myanmar; by 2035, the regional average rises from 30% to around 55%. Both heavy and light industrial activity also expands, particularly in Indonesia, Malaysia, Thailand and Viet Nam.

Figure 8.41 ▷ Energy demand and key demand drivers in Southeast Asia in the STEPS, 2015-2035



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A growing economy, expanding industry and rising living standards drive Southeast Asia's energy demand growth, which accounts for 20% of the global total to 2035

Note: AC = air conditioner.

Electricity demand in Southeast Asia rises by around 60% by 2035 in all scenarios, driven primarily by growing cooling needs, electrification of transport and expanding industry. Gas-fired generation increases by nearly 50% in the STEPS, while coal-fired generation rises by 30%. As a result, the two fuels together account for around 60% of electricity generation in 2035, down from just over 70% in 2025. Domestic fossil fuel production, however, moves in the opposite direction, with oil and gas output declining by more than 15% to 2035 in the STEPS as mature fields are depleted. These declines are partly offset in the ARC, in which regional oil and gas production is 5% higher than in the STEPS. Regional coal production falls by almost 20% in the STEPS and by 35% in the ARC as Indonesia's export market contracts

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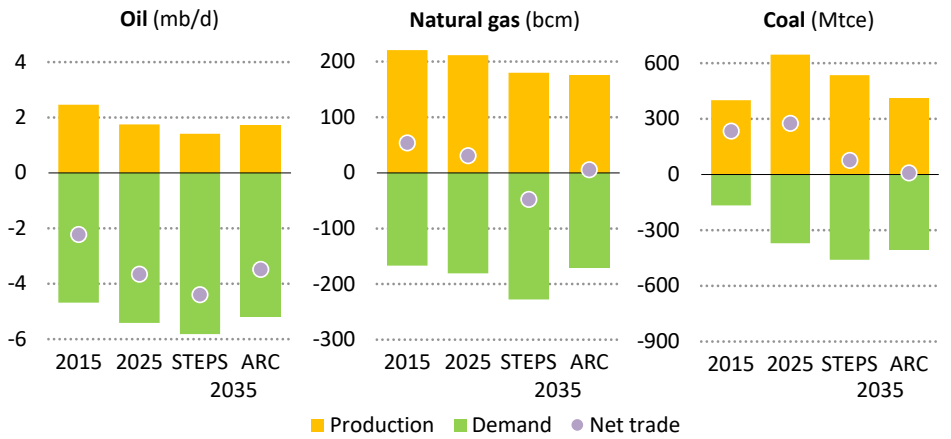
(Figure 8.42). Coal production in other Southeast Asian countries remains broadly unchanged from STEPS levels as policy shifts favour accelerated renewable deployment over additional coal development; by 2035, installed renewable capacity is more than 2.5 times higher in Indonesia and one-third higher across the rest of Southeast Asia than in the STEPS. At the regional level, renewable generation rises by 930 TWh by 2035 in the ARC, compared with 530 TWh in the STEPS.

Figure 8.42 ▷ Fossil fuel production, demand and net trade by fuel and scenario in Southeast Asia, 2015-2035



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Rising demand and declining production increase fossil fuel import dependence, but strong demand response and efforts to boost supply improve net trade positions in the ARC

The region's net fossil fuel import bill rises from around USD 80 billion in 2025 to more than USD 170 billion in 2035 in the STEPS as Southeast Asia becomes a net gas importer and as oil demand continues to grow. Higher levels of domestic production, renewables, energy efficiency and electrification reduce this bill in the ARC by more than 20%. This growing import dependence exposes the region to global fuel market disruptions such as the energy crisis triggered by interruptions to flows through the Strait of Hormuz. Before the crisis, around 45% of refined products consumed in Southeast Asia were linked to Middle Eastern supply, either through direct imports or the refining of imported crude oil. As a result, the disruption raised costs for refining, petrochemicals and fuel use. The fuels affected include LPG, which 75% of the region's population uses for cooking. Governments responded rapidly, with the Philippines declaring a national energy emergency in March 2026. All countries introduced demand-restraint measures, and some implemented price caps, tax reductions and fuel-switching measures. In our scenarios, some of these responses persist beyond the crisis, with accelerated biofuel deployment incorporated in the STEPS and, in the ARC, an extension of efforts to curb import dependence through stronger efficiency measures, electrification and faster renewable deployment.

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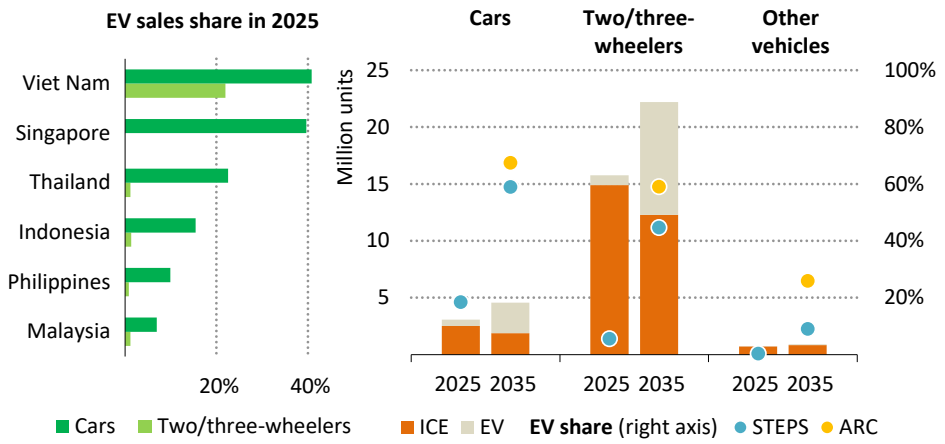
Electrifying mobility in Southeast Asia

Transport remains the main driver of oil demand growth in Southeast Asia. Since 2015, energy demand for transport has risen by around 40% in light of higher incomes and growing vehicle ownership. Oil accounts for around 90% of the sector's energy consumption, but high biofuel blending mandates in the region already helped avoid around 300 kb/d of oil demand in 2025; rising EV adoption is also reducing oil imports, improving energy security and supporting regional EV and battery manufacturing. Southeast Asia is one of the world's fastest-growing EV markets, and electric car sales more than doubled to over 550 000 vehicles in 2025. Adoption rates range from around 40% in Viet Nam and Singapore to more than 20% in Thailand and about 15% in Indonesia, reflecting differences in policy ambition, affordability and market maturity (Figure 8.43). Falling battery costs, a wider range of affordable models from both domestic and Chinese automakers, and supportive policies have all helped to drive growth.

Figure 8.43 ▷ EV sales shares in selected countries and vehicle sales by powertrain in Southeast Asia in the STEPS, 2025 and 2035



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EVs already account for nearly 20% of car sales in Southeast Asia; this grows to around 60% by 2035 in the STEPS, while annual electric two/three-wheeler sales climb to 10 million

Notes: ICE = internal combustion engine. Other vehicles include light commercial vehicles, medium freight and heavy freight trucks, and buses.

Electric car sales are projected to approach 60% of new car sales in the region by 2035 in the STEPS, while a stronger focus on energy security pushes this figure above 65% in the ARC. Higher fuel prices linked to the conflict in the Middle East are adding momentum, with Chinese EV exports between March and May 2026 up 95% year-on-year in the Philippines, 70% in Thailand and 64% in Viet Nam (BNEF, 2026). EVs avoid around 40 kb/d of oil demand today, and by 2035, this rises to around 600 kb/d in the STEPS and over 600 kb/d in the ARC, reducing annual oil import costs by more than USD 15 billion in both scenarios.

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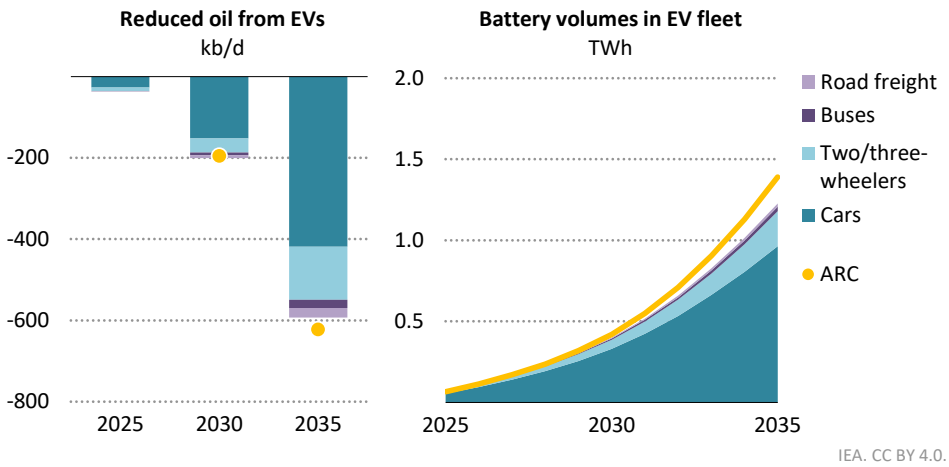
Two/three-wheelers account for around half of passenger travel in the region, offering a significant opportunity to reduce oil use. Electric models are already cost-competitive over their ownership period, but their market share remains around 5% because of concerns over reliability, resale value and model availability, and car-focused policy support. By 2035, new incentives, battery swapping programmes and restrictions on conventional vehicles lift the sales share of electric two/three-wheelers to 45% in the STEPS and 60% in the ARC. Road freight, which accounted for nearly half of transport oil demand growth over the past decade, is harder to electrify; the sales share of electric heavy-duty trucks remains below 2% in the STEPS by 2035 and rises to just under 5% in the ARC.

Figure 8.44 ▷ Reduced oil demand from EVs and battery volumes in the EV fleet in Southeast Asia in the STEPS, 2025-2035



EVs boost energy security, reducing 600 kb/d of oil demand by 2035 in the STEPS and strengthening Southeast Asia's role as a battery and EV manufacturing hub

Note: Road freight includes light commercial vehicles as well as medium freight and heavy freight trucks.

Southeast Asia is emerging as a regional EV and battery production hub, led by Indonesia, Thailand and Viet Nam and supported by industrial policies, rising demand and strong investment, particularly from China. This is helping to create new opportunities in battery manufacturing, but it could result in new supply chain dependencies, given that battery supply chains today are heavily concentrated geographically. By 2035, the region's battery manufacturing capacity in the STEPS is set to rise 50-fold to around 300 gigawatt-hours (GWh), with EV production capacity reaching close to 4 million electric cars per year, or 7% of global electric car production (IEA, 2026e). Meanwhile, battery volumes in use by the regional EV fleet rise in the STEPS from around 70 GWh today to over 1 200 GWh by 2035 (Figure 8.44). Indonesia is leveraging its nickel resources to develop battery and EV manufacturing; Thailand is strengthening its automotive production base; and Viet Nam is expanding domestic manufacturing through VinFast.

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ANNEXES

Explore the data behind WEO-2026

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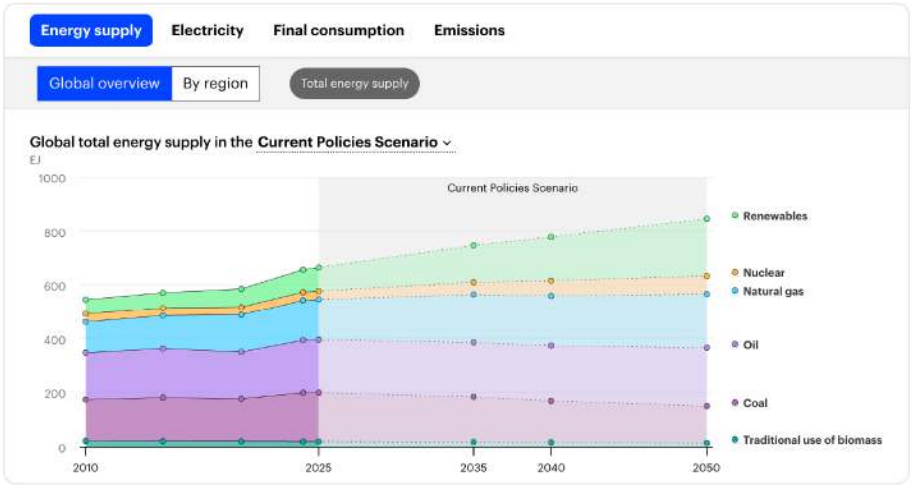

WEO-2026 datasets

Free dataset – the Annex A tables for all three scenarios with world data and selected key regions and countries, free to download: **iea.li/weo-data**

Extended dataset – go further with detailed regional and country-level projections, plus the data behind the figures, tables and slide deck of WEO-2026.
Available to purchase: **iea.li/weo-extended-data**

Model documentation and methodology are available at: **iea.li/model**

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Tables for scenario projections

General note to the tables

This annex includes global historical and projected data by scenario for the following five datasets:

- A.1: World energy supply.
- A.2: World total final consumption.
- A.3: World electricity sector: gross electricity generation and electrical capacity.
- A.4: World CO_2 emissions: carbon dioxide (CO_2) emissions from fossil fuel combustion and industrial processes.
- A.5: World economic and activity indicators.

Each dataset is given for the following scenarios: (a) Current Policies Scenario (CPS) [Tables A.1a to A.5a]; (b) Stated Policies Scenario (STEPS) [Tables A.1b to A.5b]; and (c) Net Zero Emissions by 2050 (NZE) Scenario [Tables A.1c to A.5c].

This annex also includes regional historical and projected data for the CPS and the STEPS for the following datasets:

- Tables A.6 and A.7: Total energy supply and renewables energy supply in exajoules (EJ).
- Tables A.8 to A.11: Oil production, oil demand, world liquids demand, and refining capacity and runs in million barrels per day (mb/d).
- Tables A.12 and A.13: Natural gas production and natural gas demand in billion cubic metres (bcm).
- Tables A.14 and A.15: Coal production and coal demand in million tonnes of coal equivalent (Mtce).
- Tables A.16 to A.24: Electricity demand and electricity generation by total and by source (natural gas, coal, nuclear, renewables, solar photovoltaics [PV] and wind) in terawatt-hours (TWh), with Table A.24 showing curtailment of variable renewables (wind and solar PV) in TWh and in share terms.
- Tables A.25 to A.28: Total final consumption and consumption by sector (industry, transport and buildings) in exajoules (EJ).
- Table A.29: Electrification rate.
- Tables A.30 and A.31: Useful energy demand by region, by fuel and by sector in exajoules (EJ).
- Tables A.32 and A.33: Hydrogen demand in petajoules (PJ) and the low-emissions hydrogen balance in million tonnes of hydrogen equivalent (Mt H_2 equivalent).
- Tables A.34 to A.36: Total CO_2 emissions, electricity and heat sectors CO_2 emissions, and final consumption CO_2 emissions in million tonnes of CO_2 (Mt CO_2).

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Tables A.6 to A.36 cover: World, North America, United States, Central and South America, Brazil, Europe, European Union, Africa, Middle East, Eurasia, Russia, Asia Pacific, China, India, Japan and Southeast Asia.

The definitions for regions, fuels and sectors are in Annex C.

Abbreviations and acronyms used in the tables include: CAAGR = compound average annual growth rate; CCUS = carbon capture, utilisation and storage; EJ = exajoule; GJ = gigajoule; GW = gigawatt; Mt CO_2 = million tonnes of carbon dioxide; TWh = terawatt-hour. Use of fossil fuels in facilities without CCUS is classified as "unabated".

Both in the text of this report and in these annex tables, rounding may lead to minor differences between totals and the sum of their individual components. Growth rates are calculated on a compound average annual basis and are marked "n.a." when the base year is zero or the value exceeds 200%. Nil values are marked "-".

Data sources

The Global Energy and Climate Model (GECM) is a very data-intensive model covering the whole global energy system. Detailed references on databases and publications used in the modelling and analysis may be found in Annex E.

The formal base year for this year's projections is 2024, as this is the most recent year for which a complete picture of energy demand and production is available. However, we have used more recent data wherever available, and we include our 2025 estimates for energy production and demand in this annex. Estimates for 2025 are based on the IEA *Global Energy Review 2026* report (IEA, 2026a), in which data are derived from a number of sources, including the latest monthly data submissions to the IEA Energy Data Centre, other statistical releases from national administrations, and recent market data from the IEA *Market Report Series* that cover coal, oil, natural gas, renewables and power. Investment estimates include 2026 data, based on the IEA *World Energy Investment 2026* report (IEA, 2026b). Historical data for gross power generation capacity (Table A.3) are drawn from the Power Plant Units database and the World Electric Power Plants database, both published by S&P Global Market Intelligence[1] (S&P Global, 2026); the International Atomic Energy Agency PRIS database (IAEA, 2026); and the Global Coal Plant Tracker (GEM, 2026a) and the Global Oil and Gas Plant Tracker databases (GEM, 2026b), both published by Global Energy Monitor.

Definitional note: Energy supply and transformation tables

Total energy supply (TES) is equivalent to electricity and heat generation plus the *other energy sector*, excluding electricity, heat and hydrogen, plus total final consumption,

[1] The quarterly published S&P World Electric Power Plants database has been discontinued, with March 2023 the last edition. This product has been largely subsumed into the online S&P Power Plant Units database, which is published within the suite of datasets on the S&P Capital IQ Pro platform by S&P Global Market Intelligence. As a result of this migration, historical capacity differences may be observed, in particular for fossil-fuelled power plants, compared to *World Energy Outlook 2023* and earlier editions.

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excluding electricity, heat and hydrogen. TES does not include ambient heat from heat pumps or electricity trade. *Solar* in TES includes solar PV generation, concentrating solar power (CSP) and final consumption of solar thermal. *Biofuels conversion losses* are the conversion losses to produce biofuels (mainly from modern solid bioenergy) used in the energy sector. *Low-emissions hydrogen production* is merchant low-emissions hydrogen production (excluding onsite production at industrial facilities and refineries), with inputs referring to total fuel inputs and outputs referring to produced hydrogen. While not itemised separately, *geothermal* and *marine* (tidal and wave) energy are included in the *renewables* category of TES and *electricity and heat sectors*. While not itemised separately, *non-renewable waste* and *other sources* are included in TES.

Definitional note: Energy demand tables

Sectors comprising total final consumption (TFC) include *industry* (energy use and feedstock), *transport* and *buildings* (residential, services and non-specified other). While not itemised separately, *agriculture* and *other non-energy use* are included in TFC. While not itemised separately, non-renewable waste, *solar thermal* and *geothermal* energy are included in *buildings*, *industry* and *TFC*. *Aviation* and *shipping* include both domestic and international energy demand. Energy demand from international marine and aviation bunkers is included in global transport totals and TFC.

Definitional note: Fossil fuel production and demand tables

Oil production and demand are expressed in million barrels per day (mb/d). Tight oil includes tight crude oil and condensate production except for the United States, which includes tight crude oil only (US tight condensate volumes are included in natural gas liquids). Processing gains cover volume increases that occur during crude oil refining. Biofuels, hydrogen-based fuels and their inclusion in liquids demand are expressed in energy-equivalent volumes of gasoline and diesel. Natural gas production and demand are expressed in billion cubic metres (bcm). Coal production and demand are expressed in million tonnes of coal equivalent (Mtce). Differences between historical production and demand volumes for oil, gas and coal are due to changes in stocks. Bunkers include both international marine and aviation fuels.

Definitional note: Electricity tables

Electricity generation expressed in terawatt-hours (TWh) and installed electrical capacity data expressed in gigawatts (GW) are both provided on a gross basis, i.e. include own use by the generator. Projected gross electrical capacity is the sum of existing capacity and additions, less retirements. While not itemised separately, *other sources* are included in total electricity generation. Hydrogen and ammonia are fuels that can provide a low-emissions alternative to natural gas- and coal-fired electricity generation – either through co-firing or full conversion of facilities. Blending levels of hydrogen in gas-fired plants and ammonia in coal-fired plants are represented in the scenarios and reported in the tables. The electricity generation outputs in the tables are based on fuel input shares, while the hydrogen and ammonia capacity is derived based on a typical capacity factor.

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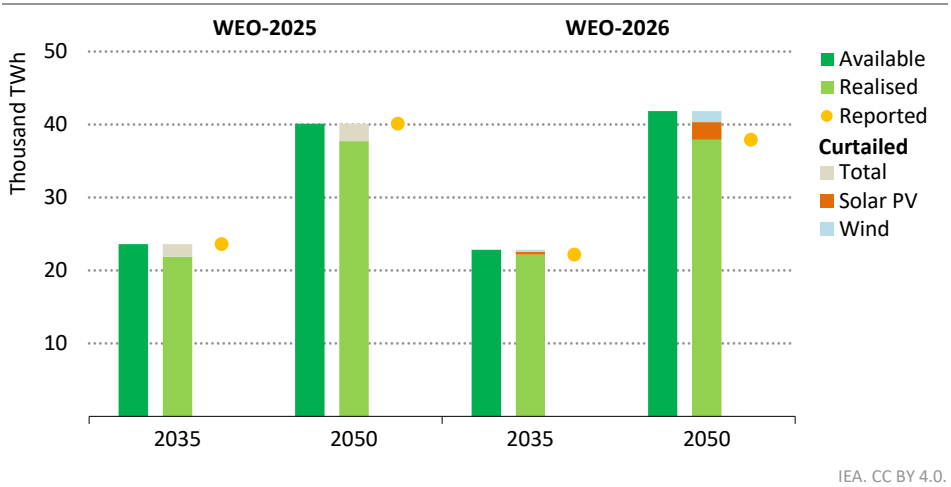
Definitional note: Curtailment of variable renewables table

The power system module in GECM has been enhanced to make the treatment of the curtailment of variable renewables (wind and solar PV) explicit in the model and reporting. In previous editions, reported wind and solar PV generation reflected available output (i.e. potential electricity generation before considering curtailment). Curtailment was modelled endogenously within the dispatch and balancing framework – ensuring that electricity supply met demand in all time periods – but was not reported separately. Table A.24 reports additional curtailment above historical levels.

Figure A.1 ▷ World renewables generation in the Stated Policies Scenario in the *WEO-2025* and *WEO-2026*, 2035 and 2050



Allocating curtailment to wind and solar PV and excluding it lowers reported renewables generation in 2035 to about 5% below WEO-2025, but realised generation is 1% higher

Note: TWh = terawatt-hour; PV = photovoltaics; WEO = World Energy Outlook.

Under the upgraded framework, generation is now reported as realised output, i.e. non-curtailed generation. This aligns reported generation more closely with system outcomes and improves transparency on the contribution of renewables.

Several related enhancements accompany this change:

- Improved curtailment representation: Curtailment better reflects power system conditions linked to the contribution of solar PV and wind power.
- Technology allocation: The model explicitly allocates curtailment between wind and solar PV.
- Consistent reporting: Published output metrics now explicitly distinguish between available and realised generation.

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These upgrades were implemented to (i) improve the clarity and interpretability of WEO results, (ii) elevate curtailment as a key policy and system design consideration, and (iii) leverage the increasing availability of empirical data on curtailment across a growing number of countries (IEA, 2026c).

This change is important when comparing *World Energy Outlook 2025* (*WEO-2025*) and *World Energy Outlook 2026* (*WEO-2026*) reported results. Measured as available generation, renewables have been revised slightly downwards in 2035 at the global level in the *WEO-2026* STEPS and revised upwards in 2050. As curtailment and available generation were not published previously, they cannot be compared directly across editions.

Definitional note: CO_2 emissions tables

Total CO_2 includes CO_2 emissions from the combustion of fossil fuels and non-renewable wastes; from industrial and fuel transformation processes (process emissions); and from flaring and CO_2 removal. CO_2 removal includes: captured and stored emissions from the combustion of bioenergy and renewable wastes; from biofuels production; and from direct air capture. *Aviation* and *shipping* include both domestic and international emissions. For Tables A.34 and A.36, the total CO_2 emissions for the world include international aviation and shipping emissions.

The first two entries are often reported as bioenergy with carbon capture and storage (BECCS). Note that some of the CO_2 captured from biofuels production and direct air capture is used to produce synthetic fuels and is not included as CO_2 removal.

Total CO_2 captured includes the CO_2 captured from CCUS facilities, such as electricity generation or industry, and atmospheric CO_2 captured through direct air capture, but it excludes that captured and used for urea production.

Definitional note: Economic and activity indicators tables

The CO_2 intensity of electricity generation expressed in grammes of carbon dioxide per kilowatt-hour (g CO_2 per kWh) is calculated based on electricity-only plants and the electricity component of combined heat and power (CHP) plants.[2] *Primary chemicals* include ethylene, propylene, aromatics, methanol and ammonia. Industrial production data for *aluminium* exclude production based on internally generated scrap. Heavy-duty trucks include medium freight trucks and heavy freight trucks. *Aviation* includes both domestic and international aviation. *Shipping* refers to international shipping.

Abbreviations used include: GDP = gross domestic product; GJ = gigajoule; m^2 = square metre; Mt = million tonnes; pkm = passenger-kilometre; PPP = purchasing power parity; tkm = tonne-kilometre.

[2] To derive the associated electricity-only emissions from CHP plants, we assume that the heat production of a CHP plant is 90% efficient and the remainder of the fuel input is allocated to electricity generation.

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Definitional note: Electrification rate table

The electrification rate is calculated as total final electricity consumption divided by total final energy consumption. Total final energy consumption corresponds to TFC excluding non-energy use.

Definitional note: Useful energy demand tables

Useful energy is the portion of energy in a system that performs the intended task. In other words, useful energy is the part of the input energy that is converted into the desired output form, accounting for end-use conversion efficiencies. Useful energy measures energy services provided by modern energy sources; it does not include non-energy use or traditional use of biomass, while they both are reported at the final consumption level.

Definitional note: Hydrogen tables

Total hydrogen demand includes merchant (or offsite) hydrogen demand and hydrogen demand in industry and refineries covered by onsite production. It also includes hydrogen used in the production of hydrogen-based fuels (ammonia and synthetic hydrocarbon fuels). The low-emissions hydrogen balance (Table A.33) is expressed in million tonnes of hydrogen equivalent, which means, for hydrogen-based fuels, the mass of hydrogen feedstock needed to produce them. Hydrogen demand in end-use sectors includes total final consumption of hydrogen and hydrogen-based fuels as well as hydrogen demand in industry covered by onsite production within industrial facilities. Low-emissions hydrogen trade as a share of demand represents the percentage of produced low-emissions hydrogen (including merchant hydrogen and that which is produced onsite in industry and refining) which is exported from the region as hydrogen or as an energy product.

Annex A licensing

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Table A.1a: World energy supply

				Current Policies (EJ)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total energy supply	**538**	**659**	**667**	**750**	**781**	**847**	**100**	**100**	**100**	**1.2**	**1.0**
Renewables	44	83	87	137	163	211	13	18	25	4.6	3.6
Solar	1	9	12	33	43	59	2	4	7	11	6.7
Wind	1	9	10	21	27	37	1	3	4	7.9	5.5
Hydro	12	16	16	18	20	23	2	2	3	1.2	1.4
Modern solid bioenergy	24	37	38	46	50	59	6	6	7	2.0	1.8
Modern liquid bioenergy	2	5	5	8	9	12	1	1	1	3.9	3.3
Modern gaseous bioenergy	1	2	2	2	3	6	0	0	1	4.2	5.1
Traditional use of biomass	21	19	19	17	16	13	3	2	2	-0.8	-1.3
Nuclear	30	31	31	46	56	67	5	6	8	3.9	3.1
Natural gas	115	149	150	179	187	200	23	24	24	1.8	1.2
Unabated	109	141	142	169	176	188	21	23	22	1.8	1.1
With CCUS	0	1	1	1	2	2	0	0	0	5.8	3.2
Oil	174	195	196	201	204	216	29	27	25	0.3	0.4
Non-energy use	26	32	33	39	42	46	5	5	5	1.8	1.4
Coal	153	180	181	167	153	137	27	22	16	-0.8	-1.1
Unabated	151	176	176	161	148	131	26	22	16	-0.9	-1.2
With CCUS	-	0	0	0	0	1	0	0	0	14	9.1
Electricity and heat sectors	**200**	**266**	**271**	**319**	**339**	**380**	**100**	**100**	**100**	**1.6**	**1.4**
Renewables	20	47	51	91	113	150	19	29	40	6.1	4.4
Solar PV	0	8	10	30	39	55	4	9	14	12	7.1
Wind	1	9	10	21	27	37	4	7	10	7.9	5.5
Hydro	12	16	16	18	20	23	6	6	6	1.2	1.4
Bioenergy	4	10	10	14	15	18	4	4	5	3.0	2.4
Hydrogen	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Ammonia	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Nuclear	30	31	31	46	56	67	11	14	18	3.9	3.1
Unabated natural gas	47	61	61	72	74	80	23	23	21	1.7	1.1
Natural gas with CCUS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Oil	11	9	9	4	3	2	3	1	1	-7.1	-5.0
Unabated coal	91	118	118	104	92	79	44	33	21	-1.3	-1.6
Coal with CCUS	-	0	0	0	0	1	0	0	0	14	9.5
Other energy sector	**51**	**67**	**68**	**80**	**84**	**94**	**100**	**100**	**100**	**1.6**	**1.3**
Biofuels conversion losses	-	7	7	9	10	13	100	100	100	3.2	2.5
Low-emissions hydrogen (offsite)											
Production inputs	-	0	0	1	2	5	100	100	100	58	26
Production outputs	-	0	0	1	2	3	100	100	100	59	27
For hydrogen-based fuels	-	0	0	0	1	2	11	41	60	81	36

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Table A.2a: World total final consumption

				Current Policies (EJ)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total final consumption	**379**	**459**	**466**	**533**	**559**	**611**	**100**	**100**	**100**	**1.4**	**1.1**
Electricity	64	96	99	135	151	179	21	25	29	3.2	2.4
Liquid fuels	154	182	184	196	201	217	39	37	36	0.7	0.7
Biofuels	2	5	5	8	9	12	1	1	2	3.9	3.3
Ammonia	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Synthetic oil	-	-	-	0	0	1	-	0	0	n.a.	n.a.
Oil	151	177	178	188	192	205	38	35	33	0.5	0.5
Gaseous fuels	57	73	74	89	95	103	16	17	17	1.9	1.3
Biomethane	0	0	0	1	1	3	0	0	0	9.1	9.7
Hydrogen	0	0	0	0	1	1	0	0	0	17	11
Synthetic methane	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Natural gas	57	73	74	88	93	99	16	17	16	1.8	1.2
Solid fuels	91	90	90	90	90	88	19	17	14	0.1	-0.1
Solid bioenergy	35	36	36	37	36	36	8	7	6	0.2	0.1
Coal	56	53	53	53	52	51	11	10	8	-0.0	-0.1
Heat	12	17	18	20	20	20	4	4	3	1.1	0.4
Industry	**142**	**175**	**177**	**206**	**215**	**231**	**100**	**100**	**100**	**1.5**	**1.1**
Electricity	27	40	41	51	54	59	23	25	25	2.1	1.4
Liquid fuels	29	34	34	40	42	47	19	19	20	1.6	1.3
Oil	29	34	34	40	42	47	19	19	20	1.6	1.3
Gaseous fuels	23	33	33	41	44	49	19	20	21	2.1	1.6
Biomethane	0	0	0	0	0	1	0	0	1	9.6	11
Hydrogen	0	0	0	0	0	0	0	0	0	11	4.6
Unabated natural gas	20	29	29	36	39	42	16	17	18	2.1	1.5
Natural gas with CCUS	0	0	0	0	0	0	0	0	0	7.0	2.8
Solid fuels	57	60	60	63	64	66	34	31	28	0.6	0.4
Modern solid bioenergy	8	11	12	14	15	17	7	7	7	1.7	1.5
Unabated coal	48	45	45	46	46	45	25	22	20	0.2	0.0
Coal with CCUS	-	0	0	0	0	0	0	0	0	3.9	0.8
Heat	5	9	10	11	11	11	5	5	5	1.4	0.6
Chemicals	37	52	54	64	67	71	30	31	31	1.8	1.2
Iron and steel	31	37	37	38	38	39	21	18	17	0.3	0.2
Cement	10	11	11	11	12	12	6	5	5	0.2	0.4
Aluminium	5	7	7	8	8	9	4	4	4	1.1	0.8

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Table A.2a: World total final consumption (continued)

				Current Policies (EJ)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Transport	**102**	**127**	**129**	**144**	**151**	**167**	**100**	**100**	**100**	**1.1**	**1.0**
Electricity	1	2	2	8	11	14	2	5	8	13	7.4
Liquid fuels	97	119	120	125	128	139	93	87	83	0.4	0.6
Biofuels	2	5	5	7	9	11	4	5	7	3.9	3.3
Oil	95	114	115	118	119	127	89	82	76	0.2	0.4
Gaseous fuels	4	6	6	11	12	14	5	7	8	5.1	3.2
Biomethane	0	0	0	0	0	1	0	0	1	9.4	8.9
Hydrogen	-	0	0	0	0	1	0	0	0	30	18
Natural gas	4	6	6	10	11	12	5	7	7	4.7	2.7
Road	76	94	96	103	107	117	74	72	70	0.7	0.8
Passenger cars	37	47	48	49	51	56	37	34	33	0.4	0.6
Heavy-duty trucks	23	30	30	35	37	42	23	24	25	1.5	1.3
Aviation	11	14	15	19	21	25	12	13	15	2.6	2.1
Shipping	11	12	12	15	16	17	9	10	10	2.0	1.4
Buildings	**113**	**129**	**131**	**150**	**158**	**176**	**100**	**100**	**100**	**1.3**	**1.2**
Electricity	35	50	51	71	80	99	39	47	56	3.3	2.7
Liquid fuels	13	13	13	12	11	11	10	8	6	-1.0	-0.6
Biofuels	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Oil	13	13	13	12	11	11	10	8	6	-1.0	-0.6
Gaseous fuels	27	29	30	32	33	34	23	22	20	0.7	0.5
Biomethane	0	0	0	0	0	1	0	0	0	8.0	8.9
Hydrogen	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Natural gas	26	29	30	32	33	33	23	21	19	0.7	0.4
Solid fuels	32	27	27	24	22	20	21	16	12	-1.2	-1.2
Modern solid bioenergy	5	5	5	5	5	6	4	3	3	-0.0	0.4
Traditional use of biomass	21	19	19	17	16	13	14	12	8	-0.8	-1.3
Coal	6	3	3	2	1	1	2	1	1	-6.6	-4.5
Heat	6	8	8	9	9	8	6	6	5	0.8	0.2
Residential	79	87	88	96	100	110	67	64	63	0.9	0.9
Services	34	42	43	54	58	66	33	36	37	2.3	1.7

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Table A.3a: World electricity sector

				Current Policies (TWh)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total generation	**21 544**	**31 459**	**32 402**	**44 124**	**49 082**	**58 548**	**100**	**100**	**100**	**3.1**	**2.4**
Renewables	4 209	9 932	10 830	20 591	25 542	34 111	33	47	58	6.6	4.7
Solar PV	33	2 089	2 723	8 347	10 934	15 150	8	19	26	12	7.1
Wind	342	2 528	2 724	5 822	7 463	10 398	8	13	18	7.9	5.5
Hydro	3 456	4 474	4 492	5 079	5 529	6 392	14	12	11	1.2	1.4
Bioenergy	309	727	773	1 064	1 193	1 452	2	2	2	3.2	2.6
of which BECCS	-	-	-	2	2	2	-	0	0	n.a.	n.a.
CSP	2	16	17	67	120	240	0	0	0	14	11
Geothermal	68	97	100	202	276	415	0	0	1	7.3	5.9
Marine	1	1	1	10	28	64	0	0	0	29	19
Nuclear	2 756	2 819	2 856	4 164	5 056	6 107	9	9	10	3.8	3.1
Hydrogen and ammonia	-	-	-	20	33	42	-	0	0	n.a.	n.a.
Fossil fuels with CCUS	-	0	4	16	25	42	0	0	0	14	9.4
Coal with CCUS	-	0	4	16	25	42	0	0	0	14	9.4
Natural gas with CCUS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Unabated fossil fuels	14 491	18 566	18 580	19 219	18 317	18 125	57	44	31	0.3	-0.1
Coal	8 677	10 910	10 864	9 933	8 767	7 750	34	23	13	-0.9	-1.3
Natural gas	4 842	6 904	6 973	8 944	9 269	10 177	22	20	17	2.5	1.5
Oil	971	753	743	342	281	198	2	1	0	-7.5	-5.1

				Current Policies (GW)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total capacity	**5 263**	**10 319**	**11 372**	**21 131**	**25 320**	**31 739**	**100**	**100**	**100**	**6.4**	**4.2**
Renewables	1 337	4 959	5 779	12 932	16 377	21 681	51	61	68	8.4	5.4
Solar PV	41	2 190	2 823	8 159	10 687	14 458	25	39	46	11	6.8
Wind	181	1 132	1 288	2 746	3 455	4 629	11	13	15	7.9	5.3
Hydro	1 026	1 427	1 453	1 734	1 891	2 151	13	8	7	1.8	1.6
Bioenergy	77	186	190	235	257	295	2	1	1	2.1	1.8
of which BECCS	-	-	-	0	0	0	-	0	0	n.a.	n.a.
CSP	1	8	8	23	36	65	0	0	0	10	8.5
Geothermal	10	15	16	31	41	59	0	0	0	6.9	5.4
Marine	0	1	1	5	11	25	0	0	0	24	17
Nuclear	402	420	421	583	694	825	4	3	3	3.3	2.7
Hydrogen and ammonia	-	-	-	5	10	12	-	0	0	n.a.	n.a.
Fossil fuels with CCUS	-	0	1	5	7	12	0	0	0	15	10
Coal with CCUS	-	0	1	5	7	12	0	0	0	15	10
Natural gas with CCUS	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Unabated fossil fuels	3 511	4 738	4 854	5 811	5 854	5 700	43	27	18	1.8	0.6
Coal	1 612	2 253	2 324	2 747	2 636	2 301	20	13	7	1.7	-0.0
Natural gas	1 478	2 081	2 130	2 776	2 975	3 225	19	13	10	2.7	1.7
Oil	420	404	399	289	243	174	4	1	1	-3.2	-3.3
Battery storage	1	182	297	1 781	2 365	3 496	3	8	11	20	10

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Table A.4a: World CO_2 emissions

				Current Policies (Mt CO_2)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2035	2050
Total CO_2*	**32 804**	**38 493**	**38 696**	**38 729**	**38 013**	**38 047**	**0.0**	**-0.1**
Combustion activities (+)	**30 567**	**35 615**	**35 833**	**35 692**	**34 869**	**34 727**	**-0.0**	**-0.1**
Coal	13 809	15 925	15 933	14 408	13 188	11 835	-1.0	-1.2
Oil	10 523	11 577	11 679	11 570	11 604	12 102	-0.1	0.1
Natural gas	6 049	7 832	7 933	9 457	9 824	10 529	1.8	1.1
Bioenergy and waste	186	281	288	258	254	262	-1.1	-0.4
Other removals (-)**	**-**	**1**	**2**	**6**	**7**	**10**	**9.3**	**5.8**
Biofuels production	-	1	2	5	6	9	8.3	5.6
Direct air capture	-	0	0	1	1	1	40	14
Electricity and heat sectors	**12 507**	**15 763**	**15 840**	**14 633**	**13 456**	**12 437**	**-0.8**	**-1.0**
Coal	8 945	11 551	11 601	10 121	8 919	7 653	-1.4	-1.7
Oil	827	654	651	313	256	179	-7.1	-5.0
Natural gas	2 621	3 409	3 438	4 076	4 160	4 473	1.7	1.1
Bioenergy and waste	113	150	150	124	120	131	-1.9	-0.5
Other energy sector**	**1 437**	**1 614**	**1 580**	**1 821**	**1 836**	**1 918**	**1.4**	**0.8**
Final consumption**	**18 600**	**20 820**	**20 958**	**22 033**	**22 482**	**23 444**	**0.5**	**0.4**
Coal	4 661	4 269	4 231	4 193	4 179	4 097	-0.1	-0.1
Oil	9 062	10 327	10 440	10 687	10 786	11 357	0.2	0.3
Natural gas	2 846	3 611	3 700	4 415	4 673	4 979	1.8	1.2
Bioenergy and waste	72	130	138	135	134	131	-0.2	-0.2
Industry**	8 213	9 081	9 043	9 813	10 132	10 505	0.8	0.6
Chemicals**	1 154	1 402	1 439	1 663	1 717	1 738	1.5	0.8
Iron and steel**	2 121	2 816	2 785	2 828	2 828	2 813	0.2	0.0
Cement**	1 980	2 237	2 172	2 236	2 335	2 495	0.3	0.6
Aluminium**	176	249	256	288	298	317	1.2	0.9
Transport	7 015	8 490	8 631	9 039	9 189	9 777	0.5	0.5
Road	5 214	6 304	6 372	6 376	6 371	6 729	0.0	0.2
Passenger cars	2 536	3 134	3 155	3 029	2 986	3 126	-0.4	-0.0
Heavy-duty trucks	1 608	1 975	2 008	2 149	2 215	2 422	0.7	0.8
Aviation	757	1 027	1 059	1 322	1 446	1 621	2.2	1.7
Shipping	795	862	906	1 042	1 065	1 102	1.4	0.8
Buildings	2 931	2 815	2 850	2 731	2 706	2 705	-0.4	-0.2
Residential	1 961	1 903	1 915	1 857	1 848	1 868	-0.3	-0.1
Services	971	912	935	874	859	837	-0.7	-0.4
Total CO_2 removals**	**-**	**1**	**3**	**8**	**8**	**12**	**12**	**6.2**
Total CO_2 captured**	**15**	**40**	**60**	**145**	**187**	**274**	**9.2**	**6.3**

*Includes industrial process and flaring emissions.

**Includes industrial process emissions.

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Table A.5a: World economic and activity indicators

				Current Policies			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2035	2050
Indicators								
Population (million)	6 988	8 122	8 192	8 843	9 133	9 618	0.8	0.6
GDP (USD 2025 billion, PPP)	131 767	203 865	210 873	283 355	321 889	402 344	3.0	2.6
GDP per capita (USD 2025, PPP)	18 857	25 099	25 742	32 044	35 243	41 831	2.2	2.0
TES/GDP (GJ per USD 1 000, PPP)	4.1	3.2	3.2	2.7	2.4	2.1	-1.7	-1.6
TFC/GDP (GJ per USD 1 000, PPP)	2.9	2.3	2.2	1.9	1.7	1.5	-1.6	-1.5
CO_2 intensity of electricity generation (g CO_2 per kWh)	527	449	436	293	240	187	-3.9	-3.3
Industrial production (Mt)								
Primary chemicals	507	750	774	942	995	1 062	2.0	1.3
Steel	1 435	1 884	1 848	2 065	2 174	2 380	1.1	1.0
Cement	3 280	3 934	3 823	4 023	4 241	4 612	0.5	0.8
Aluminium	60	113	116	140	150	170	1.9	1.6
Transport								
Passenger cars (billion pkm)	18 429	27 966	28 747	37 104	41 898	50 361	2.6	2.3
Heavy-duty trucks (billion tkm)	26 825	35 938	36 864	47 105	52 081	61 464	2.5	2.1
Aviation (billion pkm)	5 156	9 294	9 836	13 869	15 745	19 245	3.5	2.7
Shipping (billion tkm)	80 667	123 710	126 501	152 471	165 955	198 916	1.9	1.8
Buildings								
Households (million)	1 839	2 317	2 347	2 641	2 776	3 016	1.2	1.0
Residential floor area (million m^2)	161 197	214 095	217 847	255 514	273 441	305 946	1.6	1.4
Services floor area (million m^2)	41 327	62 233	63 987	78 495	84 443	93 811	2.1	1.5

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Table A.1b: World energy supply

				Stated Policies (EJ)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total energy supply	**538**	**659**	**667**	**719**	**731**	**756**	**100**	**100**	**100**	**0.8**	**0.5**
Renewables	44	83	87	143	172	223	13	20	30	5.0	3.8
Solar	1	9	12	37	49	70	2	5	9	12	7.4
Wind	1	9	10	23	30	41	1	3	5	8.8	5.9
Hydro	12	16	16	18	20	24	2	3	3	1.3	1.5
Modern solid bioenergy	24	37	38	46	49	54	6	6	7	1.9	1.5
Modern liquid bioenergy	2	5	5	8	8	10	1	1	1	4.1	2.6
Modern gaseous bioenergy	1	2	2	3	4	8	0	0	1	5.7	6.5
Traditional use of biomass	21	19	19	15	13	10	3	2	1	-2.1	-2.4
Nuclear	30	31	31	46	57	71	5	6	9	4.0	3.3
Natural gas	115	149	150	166	166	166	23	23	22	1.0	0.4
Unabated	109	141	142	156	155	154	21	22	20	0.9	0.3
With CCUS	0	1	1	2	2	2	0	0	0	7.2	4.4
Oil	174	195	196	193	188	180	29	27	24	-0.2	-0.3
Non-energy use	26	32	33	38	40	42	5	5	6	1.5	1.0
Coal	153	180	181	155	133	105	27	21	14	-1.5	-2.2
Unabated	151	176	176	150	128	100	26	21	13	-1.6	-2.2
With CCUS	-	0	0	0	0	0	0	0	0	6.5	5.1
Electricity and heat sectors	**200**	**266**	**271**	**310**	**325**	**358**	**100**	**100**	**100**	**1.3**	**1.1**
Renewables	20	47	51	98	123	166	19	32	46	6.8	4.8
Solar PV	0	8	10	34	45	64	4	11	18	13	7.8
Wind	1	9	10	23	30	41	4	7	11	8.8	5.9
Hydro	12	16	16	18	20	24	6	6	7	1.3	1.5
Bioenergy	4	10	10	14	15	19	4	4	5	3.1	2.4
Hydrogen	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Ammonia	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Nuclear	30	31	31	46	57	71	11	15	20	4.0	3.3
Unabated natural gas	47	61	61	65	63	62	23	21	17	0.7	0.1
Natural gas with CCUS	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Oil	11	9	9	4	3	2	3	1	0	-8.5	-6.6
Unabated coal	91	118	118	96	78	56	44	31	16	-2.1	-2.9
Coal with CCUS	-	0	0	0	0	0	0	0	0	-1.7	-0.9
Other energy sector	**51**	**67**	**68**	**77**	**79**	**83**	**100**	**100**	**100**	**1.2**	**0.8**
Biofuels conversion losses	-	7	7	10	10	11	100	100	100	3.6	2.0
Low-emissions hydrogen (offsite)											
Production inputs	-	0	0	2	3	5	100	100	100	61	26
Production outputs	-	0	0	1	2	4	100	100	100	62	27
For hydrogen-based fuels	-	0	0	0	1	2	11	38	54	83	36

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Table A.2b: World total final consumption

				Stated Policies (EJ)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total final consumption	**379**	**459**	**466**	**514**	**526**	**548**	**100**	**100**	**100**	**1.0**	**0.7**
Electricity	64	96	99	134	149	176	21	26	32	3.1	2.3
Liquid fuels	154	182	184	189	186	182	39	37	33	0.3	-0.0
Biofuels	2	5	5	8	8	10	1	1	2	4.1	2.6
Ammonia	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Synthetic oil	-	-	-	0	0	1	-	0	0	n.a.	n.a.
Oil	151	177	178	181	177	172	38	35	31	0.1	-0.2
Gaseous fuels	57	73	74	85	88	92	16	17	17	1.4	0.8
Biomethane	0	0	0	1	2	5	0	0	1	14	12
Hydrogen	0	0	0	0	1	1	0	0	0	20	13
Synthetic methane	-	-	-	-	-	-	-	-	-	n.a.	n.a.
Natural gas	57	73	74	83	85	85	16	16	16	1.2	0.6
Solid fuels	91	90	90	84	81	75	19	16	14	-0.7	-0.7
Solid bioenergy	35	36	36	34	33	33	8	7	6	-0.5	-0.4
Coal	56	53	53	49	46	42	11	9	8	-0.8	-0.9
Heat	12	17	18	20	20	19	4	4	3	1.1	0.3
Industry	**142**	**175**	**177**	**198**	**203**	**211**	**100**	**100**	**100**	**1.1**	**0.7**
Electricity	27	40	41	51	54	59	23	26	28	2.2	1.5
Liquid fuels	29	34	34	38	39	41	19	19	19	1.1	0.8
Oil	29	34	34	38	39	41	19	19	19	1.1	0.8
Gaseous fuels	23	33	33	38	40	43	19	19	20	1.5	1.1
Biomethane	0	0	0	0	1	2	0	0	1	14	14
Hydrogen	0	0	0	0	0	0	0	0	0	14	6.3
Unabated natural gas	20	29	29	33	35	36	16	17	17	1.4	0.8
Natural gas with CCUS	0	0	0	0	0	0	0	0	0	7.3	4.0
Solid fuels	57	60	60	59	59	57	34	30	27	-0.1	-0.2
Modern solid bioenergy	8	11	12	13	14	16	7	7	8	1.5	1.4
Unabated coal	48	45	45	42	40	37	25	21	17	-0.6	-0.8
Coal with CCUS	-	0	0	0	0	0	0	0	0	13	5.6
Heat	5	9	10	11	11	10	5	5	5	1.2	0.3
Chemicals	37	52	54	62	64	65	30	31	31	1.4	0.8
Iron and steel	31	37	37	36	36	35	21	18	17	-0.2	-0.2
Cement	10	11	11	11	11	11	6	6	5	-0.1	0.1
Aluminium	5	7	7	8	8	8	4	4	4	0.7	0.3

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Table A.2b: World total final consumption (continued)

				Stated Policies (EJ)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Transport	**102**	**127**	**129**	**140**	**142**	**146**	**100**	**100**	**100**	**0.8**	**0.5**
Electricity	1	2	2	8	12	19	2	6	13	14	8.7
Liquid fuels	97	119	120	121	118	114	93	87	78	0.1	-0.2
Biofuels	2	5	5	8	8	9	4	5	6	4.1	2.5
Oil	95	114	115	113	109	104	89	81	71	-0.1	-0.4
Gaseous fuels	4	6	6	10	12	13	5	7	9	4.8	2.9
Biomethane	0	0	0	0	1	2	0	0	1	14	11
Hydrogen	-	0	0	0	0	1	0	0	1	33	20
Natural gas	4	6	6	10	10	10	5	7	7	4.2	2.0
Road	76	94	96	100	100	100	74	72	68	0.5	0.2
Passenger cars	37	47	48	48	47	45	37	34	31	0.1	-0.2
Heavy-duty trucks	23	30	30	35	36	40	23	25	27	1.4	1.1
Aviation	11	14	15	19	21	24	12	14	17	2.8	2.0
Shipping	11	12	12	13	14	15	9	10	10	1.0	0.9
Buildings	**113**	**129**	**131**	**144**	**147**	**156**	**100**	**100**	**100**	**0.9**	**0.7**
Electricity	35	50	51	69	76	90	39	48	57	3.0	2.3
Liquid fuels	13	13	13	11	10	8	10	8	5	-1.5	-1.6
Biofuels	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Oil	13	13	13	11	10	8	10	8	5	-1.5	-1.6
Gaseous fuels	27	29	30	31	31	30	23	22	19	0.3	-0.0
Biomethane	0	0	0	0	0	1	0	0	1	13	11
Hydrogen	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Natural gas	26	29	30	31	30	28	23	21	18	0.2	-0.2
Solid fuels	32	27	27	22	19	16	21	15	11	-2.2	-2.0
Modern solid bioenergy	5	5	5	5	5	6	4	4	4	-0.2	0.3
Traditional use of biomass	21	19	19	15	13	10	14	10	6	-2.1	-2.4
Coal	6	3	3	1	1	1	2	1	0	-7.5	-6.3
Heat	6	8	8	9	9	8	6	6	5	0.9	0.3
Residential	79	87	88	92	93	97	67	64	62	0.4	0.4
Services	34	42	43	52	55	59	33	36	38	1.9	1.3

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Table A.3b: World electricity sector

				Stated Policies (TWh)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total generation	**21 544**	**31 459**	**32 402**	**43 964**	**48 798**	**57 800**	**100**	**100**	**100**	**3.1**	**2.3**
Renewables	4 209	9 932	10 830	22 174	28 071	37 919	33	50	66	7.4	5.1
Solar PV	33	2 089	2 723	9 381	12 606	17 764	8	21	31	13	7.8
Wind	342	2 528	2 724	6 328	8 242	11 358	8	14	20	8.8	5.9
Hydro	3 456	4 474	4 492	5 104	5 564	6 533	14	12	11	1.3	1.5
Bioenergy	309	727	773	1 067	1 202	1 482	2	2	3	3.3	2.6
of which BECCS	-	-	-	2	2	2	-	0	0	n.a.	n.a.
CSP	2	16	17	69	127	253	0	0	0	15	11
Geothermal	68	97	100	214	300	457	0	0	1	7.9	6.3
Marine	1	1	1	11	31	73	0	0	0	30	20
Nuclear	2 756	2 819	2 856	4 203	5 189	6 439	9	10	11	3.9	3.3
Hydrogen and ammonia	-	-	-	44	70	80	-	0	0	n.a.	n.a.
Fossil fuels with CCUS	-	0	4	19	28	45	0	0	0	16	9.7
Coal with CCUS	-	0	4	16	25	42	0	0	0	14	9.4
Natural gas with CCUS	-	-	-	3	3	3	-	0	0	n.a.	n.a.
Unabated fossil fuels	14 491	18 566	18 580	17 437	15 368	13 252	57	40	23	-0.6	-1.3
Coal	8 677	10 910	10 864	9 101	7 285	5 146	34	21	9	-1.8	-2.9
Natural gas	4 842	6 904	6 973	8 047	7 847	7 982	22	18	14	1.4	0.5
Oil	971	753	743	289	236	124	2	1	0	-9.0	-6.9

				Stated Policies (GW)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total capacity	**5 263**	**10 319**	**11 372**	**22 150**	**26 987**	**34 442**	**100**	**100**	**100**	**6.9**	**4.5**
Renewables	1 337	4 959	5 779	13 804	17 792	24 031	51	62	70	9.1	5.9
Solar PV	41	2 190	2 823	8 845	11 818	16 399	25	40	48	12	7.3
Wind	181	1 132	1 288	2 909	3 699	4 945	11	13	14	8.5	5.5
Hydro	1 026	1 427	1 453	1 750	1 922	2 224	13	8	6	1.9	1.7
Bioenergy	77	186	190	238	259	301	2	1	1	2.3	1.9
of which BECCS	-	-	-	0	0	0	-	0	0	n.a.	n.a.
CSP	1	8	8	23	37	68	0	0	0	11	8.7
Geothermal	10	15	16	33	44	65	0	0	0	7.5	5.8
Marine	0	1	1	5	13	28	0	0	0	25	17
Nuclear	402	420	421	592	721	886	4	3	3	3.4	3.0
Hydrogen and ammonia	-	-	-	13	21	30	-	0	0	n.a.	n.a.
Fossil fuels with CCUS	-	0	1	5	8	13	0	0	0	17	10
Coal with CCUS	-	0	1	5	7	12	0	0	0	15	10
Natural gas with CCUS	-	-	-	1	1	1	-	0	0	n.a.	n.a.
Unabated fossil fuels	3 511	4 738	4 854	5 579	5 464	4 998	43	25	15	1.4	0.1
Coal	1 612	2 253	2 324	2 669	2 521	2 021	20	12	6	1.4	-0.6
Natural gas	1 478	2 081	2 130	2 639	2 716	2 847	19	12	8	2.2	1.2
Oil	420	404	399	271	227	131	4	1	0	-3.8	-4.4
Battery storage	1	182	297	2 148	2 975	4 481	3	10	13	22	11

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Table A.4b: World CO_2 emissions

				Stated Policies (Mt CO_2)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2035	2050
Total CO_2*	**32 804**	**38 493**	**38 696**	**36 219**	**33 795**	**30 463**	**-0.7**	**-1.0**
Combustion activities (+)	**30 567**	**35 615**	**35 833**	**33 239**	**30 749**	**27 354**	**-0.7**	**-1.1**
Coal	13 809	15 925	15 933	13 273	11 312	8 727	-1.8	-2.4
Oil	10 523	11 577	11 679	11 032	10 563	9 869	-0.6	-0.7
Natural gas	6 049	7 832	7 933	8 716	8 680	8 589	0.9	0.3
Bioenergy and waste	186	281	288	218	194	170	-2.7	-2.1
Other removals (-)**	**-**	**1**	**2**	**6**	**6**	**10**	**9.4**	**5.9**
Biofuels production	-	1	2	5	6	9	8.4	5.7
Direct air capture	-	0	0	1	1	1	40	14
Electricity and heat sectors	**12 507**	**15 763**	**15 840**	**13 394**	**11 454**	**9 125**	**-1.7**	**-2.2**
Coal	8 945	11 551	11 601	9 357	7 610	5 440	-2.1	-3.0
Oil	827	654	651	270	220	121	-8.4	-6.5
Natural gas	2 621	3 409	3 438	3 681	3 557	3 511	0.7	0.1
Bioenergy and waste	113	150	150	87	67	53	-5.3	-4.1
Other energy sector**	**1 437**	**1 614**	**1 580**	**1 711**	**1 684**	**1 616**	**0.8**	**0.1**
Final consumption**	**18 600**	**20 820**	**20 958**	**20 886**	**20 445**	**19 541**	**-0.0**	**-0.3**
Coal	4 661	4 269	4 231	3 825	3 616	3 210	-1.0	-1.1
Oil	9 062	10 327	10 440	10 218	9 817	9 262	-0.2	-0.5
Natural gas	2 846	3 611	3 700	4 153	4 246	4 215	1.2	0.5
Bioenergy and waste	72	130	138	131	127	117	-0.5	-0.6
Industry**	8 213	9 081	9 043	9 189	9 178	8 917	0.2	-0.1
Chemicals**	1 154	1 402	1 439	1 557	1 552	1 441	0.8	0.0
Iron and steel**	2 121	2 816	2 785	2 627	2 534	2 325	-0.6	-0.7
Cement**	1 980	2 237	2 172	2 189	2 256	2 344	0.1	0.3
Aluminium**	176	249	256	274	273	266	0.7	0.2
Transport	7 015	8 490	8 631	8 685	8 419	8 035	0.1	-0.3
Road	5 214	6 304	6 372	6 126	5 775	5 254	-0.4	-0.8
Passenger cars	2 536	3 134	3 155	2 903	2 682	2 331	-0.8	-1.2
Heavy-duty trucks	1 608	1 975	2 008	2 112	2 129	2 199	0.5	0.4
Aviation	757	1 027	1 059	1 332	1 426	1 549	2.3	1.5
Shipping	795	862	906	943	934	948	0.4	0.2
Buildings	2 931	2 815	2 850	2 598	2 449	2 224	-0.9	-1.0
Residential	1 961	1 903	1 915	1 771	1 680	1 544	-0.8	-0.9
Services	971	912	935	827	769	680	-1.2	-1.3
Total CO_2 removals**	**-**	**1**	**3**	**8**	**10**	**16**	**13**	**7.6**
Total CO_2 captured**	**15**	**40**	**60**	**169**	**225**	**347**	**11**	**7.3**

*Includes industrial process and flaring emissions.

**Includes industrial process emissions.

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Table A.5b: World economic and activity indicators

				Stated Policies			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2035	2050
Indicators								
Population (million)	6 988	8 122	8 192	8 843	9 133	9 618	0.8	0.6
GDP (USD 2025 billion, PPP)	131 767	203 865	210 873	283 355	321 889	402 344	3.0	2.6
GDP per capita (USD 2025, PPP)	18 857	25 099	25 742	32 044	35 243	41 831	2.2	2.0
TES/GDP (GJ per USD 1 000, PPP)	4.1	3.2	3.2	2.5	2.3	1.9	-2.2	-2.1
TFC/GDP (GJ per USD 1 000, PPP)	2.9	2.3	2.2	1.8	1.6	1.4	-1.9	-1.9
CO_2 intensity of electricity generation (g CO_2 per kWh)	527	449	436	267	202	135	-4.8	-4.6
Industrial production (Mt)								
Primary chemicals	507	750	774	925	972	1 021	1.8	1.1
Steel	1 435	1 884	1 848	2 065	2 174	2 380	1.1	1.0
Cement	3 280	3 934	3 823	4 023	4 241	4 612	0.5	0.8
Aluminium	60	113	116	140	150	170	1.9	1.6
Transport								
Passenger cars (billion pkm)	18 429	27 966	28 747	37 191	42 061	50 716	2.6	2.3
Heavy-duty trucks (billion tkm)	26 825	35 938	36 864	47 172	52 146	61 553	2.5	2.1
Aviation (billion pkm)	5 156	9 294	9 836	14 089	16 270	20 560	3.7	3.0
Shipping (billion tkm)	80 667	123 710	126 501	146 567	156 331	181 961	1.5	1.5
Buildings								
Households (million)	1 839	2 317	2 347	2 641	2 776	3 016	1.2	1.0
Residential floor area (million m^2)	161 197	214 095	217 847	255 514	273 441	305 946	1.6	1.4
Services floor area (million m^2)	41 327	62 233	63 987	78 495	84 443	93 811	2.1	1.5

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Table A.1c: World energy supply

				Net Zero Emissions by 2050 (EJ)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total energy supply	**538**	**659**	**667**	**607**	**576**	**570**	**100**	**100**	**100**	**-0.9**	**-0.6**
Renewables	44	83	87	227	290	376	13	37	66	10	6.0
Solar	1	9	12	64	95	134	2	11	24	19	10
Wind	1	9	10	44	61	80	1	7	14	16	8.7
Hydro	12	16	16	21	23	27	2	3	5	2.7	2.1
Modern solid bioenergy	24	37	38	62	67	76	6	10	13	5.0	2.8
Modern liquid bioenergy	2	5	5	15	14	13	1	3	2	12	3.7
Modern gaseous bioenergy	1	2	2	5	9	15	0	1	3	13	9.5
Traditional use of biomass	21	19	19	3	0	-	3	1	-	-17	n.a.
Nuclear	30	31	31	65	85	99	5	11	17	7.6	4.7
Natural gas	115	149	150	92	61	30	23	15	5	-4.8	-6.3
Unabated	109	141	142	77	42	8	21	13	1	-6.0	-11
With CCUS	0	1	1	7	11	15	0	1	3	25	12
Oil	174	195	196	140	102	50	29	23	9	-3.3	-5.4
Non-energy use	26	32	33	33	32	28	5	5	5	0.1	-0.6
Coal	153	180	181	78	36	16	27	13	3	-8.0	-9.4
Unabated	151	176	176	68	22	4	26	11	1	-9.1	-14
With CCUS	-	0	0	7	10	10	0	1	2	59	22
Electricity and heat sectors	**200**	**266**	**271**	**293**	**329**	**409**	**100**	**100**	**100**	**0.8**	**1.6**
Renewables	20	47	51	161	219	294	19	55	72	12	7.3
Solar PV	0	8	10	58	84	115	4	20	28	19	10
Wind	1	9	10	44	61	80	4	15	19	16	8.7
Hydro	12	16	16	21	23	27	6	7	7	2.7	2.1
Bioenergy	4	10	10	23	28	35	4	8	9	8.3	5.1
Hydrogen	-	-	-	2	3	4	-	1	1	n.a.	n.a.
Ammonia	-	-	-	1	1	2	-	0	0	n.a.	n.a.
Nuclear	30	31	31	65	85	99	11	22	24	7.6	4.7
Unabated natural gas	47	61	61	25	10	3	23	8	1	-8.7	-12
Natural gas with CCUS	-	-	-	1	2	2	-	0	0	n.a.	n.a.
Oil	11	9	9	1	0	0	3	0	0	-21	-25
Unabated coal	91	118	118	31	0	-	44	11	-	-13	n.a.
Coal with CCUS	-	0	0	5	7	6	0	2	1	57	21
Other energy sector	**51**	**67**	**68**	**82**	**93**	**116**	**100**	**100**	**100**	**2.0**	**2.2**
Biofuels conversion losses	-	7	7	18	17	14	100	100	100	10	3.1
Low-emissions hydrogen (offsite)											
Production inputs	-	0	0	17	28	44	100	100	100	102	38
Production outputs	-	0	0	11	19	32	100	100	100	103	39
For hydrogen-based fuels	-	0	0	5	10	19	11	50	58	137	48

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Table A.2c: World total final consumption

				Net Zero Emissions by 2050 (EJ)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total final consumption	**379**	**459**	**466**	**439**	**408**	**374**	**100**	**100**	**100**	**-0.6**	**-0.9**
Electricity	64	96	99	139	165	205	21	32	55	3.5	3.0
Liquid fuels	154	182	184	151	118	71	39	34	19	-1.9	-3.7
Biofuels	2	5	5	15	14	13	1	4	3	12	3.7
Ammonia	-	-	-	1	2	3	-	0	1	n.a.	n.a.
Synthetic oil	-	-	-	1	2	6	-	0	2	n.a.	n.a.
Oil	151	177	178	133	98	48	38	30	13	-2.9	-5.1
Gaseous fuels	57	73	74	63	53	39	16	14	10	-1.6	-2.6
Biomethane	0	0	0	3	6	11	0	1	3	26	16
Hydrogen	0	0	0	3	5	9	0	1	2	43	22
Synthetic methane	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Natural gas	57	73	74	57	41	16	16	13	4	-2.6	-5.9
Solid fuels	91	90	90	63	50	36	19	14	10	-3.5	-3.6
Solid bioenergy	35	36	36	25	24	27	8	6	7	-3.6	-1.1
Coal	56	53	53	37	25	9	11	9	2	-3.4	-6.8
Heat	12	17	18	17	15	12	4	4	3	-0.5	-1.7
Industry	**142**	**175**	**177**	**181**	**174**	**161**	**100**	**100**	**100**	**0.2**	**-0.4**
Electricity	27	40	41	57	66	81	23	32	50	3.3	2.7
Liquid fuels	29	34	34	32	30	24	19	18	15	-0.5	-1.4
Oil	29	34	34	32	29	22	19	18	14	-0.6	-1.7
Gaseous fuels	23	33	33	30	26	20	19	17	12	-0.9	-2.0
Biomethane	0	0	0	1	2	4	0	1	2	29	16
Hydrogen	0	0	0	1	3	4	0	1	3	37	19
Unabated natural gas	20	29	29	23	15	3	16	12	2	-2.5	-8.2
Natural gas with CCUS	0	0	0	1	3	5	0	1	3	36	20
Solid fuels	57	60	60	51	42	29	34	28	18	-1.5	-2.8
Modern solid bioenergy	8	11	12	16	19	21	7	9	13	3.4	2.5
Unabated coal	48	45	45	31	18	3	25	17	2	-3.7	-11
Coal with CCUS	-	0	0	2	3	4	0	1	3	63	26
Heat	5	9	10	8	7	4	5	5	2	-1.5	-3.7
Chemicals	37	52	54	56	55	51	30	31	32	0.3	-0.2
Iron and steel	31	37	37	33	30	25	21	18	15	-1.2	-1.6
Cement	10	11	11	11	11	10	6	6	6	-0.3	-0.4
Aluminium	5	7	7	7	6	6	4	4	3	-0.3	-1.1

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Table A.2c: World total final consumption (continued)

				Net Zero Emissions by 2050 (EJ)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Transport	**102**	**127**	**129**	**114**	**96**	**79**	**100**	**100**	**100**	**-1.2**	**-1.9**
Electricity	1	2	2	13	23	38	2	12	48	19	12
Liquid fuels	97	119	120	95	69	35	93	84	45	-2.3	-4.8
Biofuels	2	5	5	14	12	10	4	13	12	11	2.6
Oil	95	114	115	78	51	15	89	68	19	-3.8	-7.7
Gaseous fuels	4	6	6	5	4	6	5	5	7	-1.6	-0.4
Biomethane	0	0	0	1	1	0	0	1	1	17	5.6
Hydrogen	-	0	0	1	2	5	0	1	6	56	27
Natural gas	4	6	6	4	2	0	5	3	0	-5.0	-11
Road	76	94	96	80	64	49	74	70	62	-1.7	-2.6
Passenger cars	37	47	48	37	27	18	37	33	22	-2.5	-3.9
Heavy-duty trucks	23	30	30	30	27	24	23	26	30	-0.1	-0.9
Aviation	11	14	15	19	18	16	12	17	21	2.4	0.4
Shipping	11	12	12	10	10	9	9	9	12	-1.9	-1.1
Buildings	**113**	**129**	**131**	**115**	**111**	**110**	**100**	**100**	**100**	**-1.3**	**-0.7**
Electricity	35	50	51	64	70	81	39	55	73	2.2	1.8
Liquid fuels	13	13	13	8	6	2	10	7	2	-4.2	-7.8
Biofuels	-	-	-	0	0	1	-	0	1	n.a.	n.a.
Oil	13	13	13	8	5	1	10	7	1	-4.3	-9.2
Gaseous fuels	27	29	30	23	17	9	23	20	8	-2.9	-4.9
Biomethane	0	0	0	1	3	7	0	1	6	29	19
Hydrogen	-	-	-	0	0	0	-	0	0	n.a.	n.a.
Natural gas	26	29	30	21	13	0	23	18	0	-3.6	-16
Solid fuels	32	27	27	9	5	5	21	8	4	-11	-6.6
Modern solid bioenergy	5	5	5	5	5	5	4	4	4	-0.6	-0.3
Traditional use of biomass	21	19	19	3	0	-	14	3	-	-17	n.a.
Coal	6	3	3	1	0	0	2	1	0	-13	-20
Heat	6	8	8	8	8	8	6	7	7	0.6	-0.0
Residential	79	87	88	70	66	66	67	61	60	-2.2	-1.1
Services	34	42	43	45	44	44	33	39	40	0.4	0.1

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Table A.3c: World electricity sector

				Net Zero Emissions by 2050 (TWh)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total generation	**21 544**	**31 459**	**32 402**	**48 745**	**59 629**	**76 500**	**100**	**100**	**100**	**4.2**	**3.5**
Renewables	4 209	9 932	10 830	36 474	50 016	66 340	33	75	87	13	7.5
Solar PV	33	2 089	2 723	16 048	23 211	31 831	8	33	42	19	10
Wind	342	2 528	2 724	12 146	16 895	22 093	8	25	29	16	8.7
Hydro	3 456	4 474	4 492	5 837	6 514	7 489	14	12	10	2.7	2.1
Bioenergy	309	727	773	1 787	2 241	2 869	2	4	4	8.7	5.4
of which BECCS	-	-	-	378	548	733	-	1	1	n.a.	n.a.
CSP	2	16	17	275	621	1 195	0	1	2	32	18
Geothermal	68	97	100	361	490	772	0	1	1	14	8.5
Marine	1	1	1	20	44	92	0	0	0	38	21
Nuclear	2 756	2 819	2 856	5 407	6 911	8 318	9	11	11	6.6	4.4
Hydrogen and ammonia	-	-	-	426	602	656	-	1	1	n.a.	n.a.
Fossil fuels with CCUS	-	0	4	580	847	762	0	1	1	63	23
Coal with CCUS	-	0	4	419	600	502	0	1	1	57	21
Natural gas with CCUS	-	-	-	162	247	260	-	0	0	n.a.	n.a.
Unabated fossil fuels	14 491	18 566	18 580	5 776	1 167	331	57	12	0	-11	-15
Coal	8 677	10 910	10 864	2 892	-	-	34	6	-	-12	n.a.
Natural gas	4 842	6 904	6 973	2 821	1 162	331	22	6	0	-8.7	-11
Oil	971	753	743	63	5	1	2	0	0	-22	-25

				Net Zero Emissions by 2050 (GW)			Shares (%)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2025	2035	2050	2035	2050
Total capacity	**5 263**	**10 319**	**11 372**	**28 478**	**37 325**	**47 887**	**100**	**100**	**100**	**9.6**	**5.9**
Renewables	1 337	4 959	5 779	20 518	28 404	37 355	51	72	78	14	7.8
Solar PV	41	2 190	2 823	12 927	18 457	24 905	25	45	52	16	9.1
Wind	181	1 132	1 288	5 014	6 880	8 735	11	18	18	15	8.0
Hydro	1 026	1 427	1 453	2 028	2 306	2 623	13	7	5	3.4	2.4
Bioenergy	77	186	190	390	476	604	2	1	1	7.4	4.7
of which BECCS	-	-	-	73	98	127	-	0	0	n.a.	n.a.
CSP	1	8	8	90	183	330	0	0	1	27	16
Geothermal	10	15	16	60	85	122	0	0	0	14	8.5
Marine	0	1	1	8	17	36	0	0	0	32	18
Nuclear	402	420	421	734	979	1 203	4	3	3	5.7	4.3
Hydrogen and ammonia	-	-	-	288	360	360	-	1	1	n.a.	n.a.
Fossil fuels with CCUS	-	0	1	123	181	201	0	0	0	60	23
Coal with CCUS	-	0	1	82	118	130	0	0	0	54	21
Natural gas with CCUS	-	-	-	41	63	71	-	0	0	n.a.	n.a.
Unabated fossil fuels	3 511	4 738	4 854	3 472	2 533	1 660	43	12	3	-3.3	-4.2
Coal	1 612	2 253	2 324	1 363	813	313	20	5	1	-5.2	-7.7
Natural gas	1 478	2 081	2 130	1 933	1 612	1 306	19	7	3	-1.0	-1.9
Oil	420	404	399	176	107	41	4	1	0	-7.9	-8.7
Battery storage	1	182	297	3 335	4 860	7 099	3	12	15	27	14

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Table A.4c: World CO_2 emissions

				Net Zero Emissions by 2050 (Mt CO_2)			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2035	2050
Total CO_2*	**32 804**	**38 493**	**38 696**	**18 965**	**9 133**	**-**	**-6.9**	**n.a.**
Combustion activities (+)	**30 567**	**35 615**	**35 833**	**17 495**	**8 601**	**1 522**	**-6.9**	**-12**
Coal	13 809	15 925	15 933	5 806	1 689	267	-9.6	-15
Oil	10 523	11 577	11 679	7 516	4 915	1 523	-4.3	-7.8
Natural gas	6 049	7 832	7 933	4 320	2 371	437	-5.9	-11
Bioenergy and waste	186	281	288	- 147	- 374	- 705	n.a.	n.a.
Other removals (-)**	**-**	**1**	**2**	**401**	**730**	**1 892**	**67**	**31**
Biofuels production	-	1	2	190	242	318	55	22
Direct air capture	-	0	0	211	488	1 574	153	57
Electricity and heat sectors	**12 507**	**15 763**	**15 840**	**4 303**	**308**	**- 271**	**-12**	**-185**
Coal	8 945	11 551	11 601	3 038	43	16	-13	-23
Oil	827	654	651	64	11	1	-21	-24
Natural gas	2 621	3 409	3 438	1 387	555	148	-8.7	-12
Bioenergy and waste	113	150	150	- 186	- 300	- 436	n.a.	n.a.
Other energy sector**	**1 437**	**1 614**	**1 580**	**457**	**155**	**- 101**	**-12**	**-190**
Final consumption**	**18 600**	**20 820**	**20 958**	**14 409**	**9 153**	**1 935**	**-3.7**	**-9.1**
Coal	4 661	4 269	4 231	2 738	1 628	240	-4.3	-11
Oil	9 062	10 327	10 440	7 108	4 662	1 392	-3.8	-7.7
Natural gas	2 846	3 611	3 700	2 661	1 679	212	-3.2	-11
Bioenergy and waste	72	130	138	39	- 74	- 268	-12	n.a.
Industry**	8 213	9 081	9 043	6 531	4 127	678	-3.2	-9.8
Chemicals**	1 154	1 402	1 439	1 054	686	93	-3.1	-10
Iron and steel**	2 121	2 816	2 785	1 956	1 228	210	-3.5	-9.8
Cement**	1 980	2 237	2 172	1 498	884	103	-3.6	-11
Aluminium**	176	249	256	219	140	11	-1.5	-12
Transport	7 015	8 490	8 631	5 812	3 741	1 119	-3.9	-7.8
Road	5 214	6 304	6 372	4 171	2 543	632	-4.1	-8.8
Passenger cars	2 536	3 134	3 155	1 878	1 054	238	-5.1	-9.8
Heavy-duty trucks	1 608	1 975	2 008	1 652	1 200	361	-1.9	-6.6
Aviation	757	1 027	1 059	1 129	892	366	0.6	-4.2
Shipping	795	862	906	368	209	95	-8.6	-8.6
Buildings	2 931	2 815	2 850	1 804	1 113	109	-4.5	-12
Residential	1 961	1 903	1 915	1 219	746	73	-4.4	-12
Services	971	912	935	585	367	36	-4.6	-12
Total CO_2 removals**	**-**	**1**	**3**	**704**	**1 232**	**2 689**	**75**	**32**
Total CO_2 captured**	**15**	**40**	**60**	**2 176**	**3 853**	**6 376**	**43**	**21**

*Includes industrial process and flaring emissions.

**Includes industrial process emissions.

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Table A.5c: World economic and activity indicators

				Net Zero Emissions by 2050			CAAGR (%) 2025 to:	
	2010	2024	2025	2035	2040	2050	2035	2050
Indicators								
Population (million)	6 988	8 122	8 192	8 843	9 133	9 618	0.8	0.6
GDP (USD 2025 billion, PPP)	131 767	203 865	210 873	283 355	321 889	402 344	3.0	2.6
GDP per capita (USD 2025, PPP)	18 857	25 099	25 742	32 044	35 243	41 831	2.2	2.0
TES/GDP (GJ per USD 1 000, PPP)	4.1	3.2	3.2	2.1	1.8	1.4	-3.8	-3.1
TFC/GDP (GJ per USD 1 000, PPP)	2.9	2.3	2.2	1.6	1.3	0.9	-3.5	-3.4
CO_2 intensity of electricity generation (g CO_2 per kWh)	527	449	436	74	3	- 4	-16	-183
Industrial production (Mt)								
Primary chemicals	507	750	774	864	878	840	1.1	0.3
Steel	1 435	1 884	1 848	1 920	1 912	1 880	0.4	0.1
Cement	3 280	3 934	3 823	3 722	3 685	3 637	-0.3	-0.2
Aluminium	60	113	116	141	149	160	2.0	1.3
Transport								
Passenger cars (billion pkm)	18 429	27 966	28 747	35 653	38 782	43 811	2.2	1.7
Heavy-duty trucks (billion tkm)	26 825	35 938	36 864	46 799	51 758	61 115	2.4	2.0
Aviation (billion pkm)	5 156	9 294	9 836	13 865	14 093	15 622	3.5	1.9
Shipping (billion tkm)	80 667	123 710	126 501	119 800	120 061	132 785	-0.5	0.2
Buildings								
Households (million)	1 839	2 317	2 347	2 641	2 776	3 016	1.2	1.0
Residential floor area (million m^2)	161 197	214 095	217 847	255 514	273 441	305 946	1.6	1.4
Services floor area (million m^2)	41 327	62 233	63 987	78 495	84 443	93 811	2.1	1.5

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Table A.6: Total energy supply (EJ)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**537.9**	**659.0**	**667.0**	**749.5**	**847.2**	**719.5**	**756.1**
North America	112.6	115.0	117.0	125.7	137.7	120.5	119.7
United States	94.1	94.4	96.2	103.9	113.8	99.5	98.5
Central and South America	26.7	30.8	31.1	37.7	47.2	36.5	42.3
Brazil	12.2	15.2	15.5	18.8	23.1	18.2	20.6
Europe	89.3	74.7	74.6	73.2	71.5	71.1	66.3
European Union	64.5	53.1	53.0	50.2	47.1	49.0	44.1
Africa	25.7	34.7	35.7	43.5	60.3	41.2	51.8
Middle East	26.1	37.2	37.7	45.2	59.2	43.4	53.3
Eurasia	37.0	44.3	44.0	46.0	47.4	45.0	44.5
Russia	30.4	35.8	35.3	35.6	34.3	34.7	32.2
Asia Pacific	205.3	304.4	308.5	355.1	395.9	339.7	353.0
China	107.0	174.5	177.6	192.6	190.0	185.5	170.5
India	27.8	48.6	49.1	66.9	89.2	62.8	78.2
Japan	20.9	15.6	15.6	14.6	13.8	13.9	12.0
Southeast Asia	21.3	34.2	35.1	46.4	61.6	45.0	56.0

Table A.7: Renewables energy supply (EJ)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**44.3**	**83.3**	**87.4**	**136.9**	**211.5**	**143.0**	**223.4**
North America	8.8	13.4	13.6	18.4	25.6	19.2	25.4
United States	6.6	10.9	11.0	14.9	20.8	15.4	20.3
Central and South America	7.7	11.1	11.3	15.1	20.4	15.2	20.5
Brazil	5.6	8.0	8.1	10.6	13.3	10.6	12.8
Europe	9.9	15.6	15.7	21.5	28.1	22.9	29.8
European Union	7.8	11.4	11.5	15.8	20.5	16.8	21.6
Africa	3.7	6.1	6.3	9.6	17.0	9.3	16.6
Middle East	0.1	0.3	0.4	1.4	3.4	1.8	4.6
Eurasia	2.2	2.4	2.4	2.6	3.0	2.7	3.2
Russia	2.0	2.1	2.1	2.0	2.0	2.0	2.0
Asia Pacific	11.8	34.2	37.6	67.6	111.6	71.2	120.8
China	4.3	17.7	19.8	36.7	56.3	38.7	61.5
India	2.7	6.6	7.4	13.4	25.8	13.7	26.5
Japan	0.8	1.3	1.4	2.0	2.5	2.2	2.9
Southeast Asia	2.8	6.3	6.6	10.7	18.0	11.4	19.7

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Table A.8: Oil production (mb/d)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World supply	**85.3**	**99.8**	**103.1**	**106.2**	**114.0**	**101.7**	**95.6**
Processing gains	2.1	2.4	2.4	2.9	3.7	2.6	2.9
World production	**83.3**	**97.5**	**100.7**	**103.3**	**110.3**	**99.1**	**92.7**
Conventional crude oil	67.0	62.0	64.0	59.5	66.7	57.0	53.5
Tight oil	0.7	9.8	10.0	11.9	12.2	11.8	10.9
Natural gas liquids	12.5	20.5	21.2	25.2	23.8	23.7	21.4
Extra-heavy oil and bitumen	2.6	4.2	4.5	5.2	6.2	5.1	5.4
Non-OPEC+	36.1	51.8	53.9	59.0	55.6	56.6	49.3
OPEC+	47.2	45.7	46.8	44.3	54.7	42.5	43.4
North America	14.0	28.5	29.5	31.4	29.0	29.9	26.3
Central and South America	7.4	7.4	8.0	10.8	11.3	10.3	9.8
Europe	4.4	3.4	3.5	2.6	1.4	2.4	1.1
European Union	0.7	0.4	0.5	0.4	0.3	0.4	0.2
Africa	10.3	7.1	7.4	7.4	7.3	6.6	5.8
Middle East	25.4	30.2	31.3	33.0	42.1	32.1	35.2
Eurasia	13.4	13.5	13.6	12.0	14.2	11.8	10.3
Asia Pacific	8.4	7.5	7.5	6.1	5.0	5.9	4.2
Southeast Asia	2.6	1.7	1.8	1.5	1.5	1.4	1.0

Table A.9: Oil demand (mb/d)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**87.4**	**101.2**	**102.2**	**106.2**	**114.0**	**101.7**	**95.6**
North America	22.2	22.1	22.4	22.9	23.1	22.0	18.6
United States	17.8	17.9	18.2	18.9	19.0	18.1	15.2
Central and South America	5.5	5.6	5.7	6.5	8.1	6.2	6.7
Brazil	2.2	2.5	2.5	2.7	3.3	2.6	2.7
Europe	13.8	12.3	12.2	9.7	6.2	9.5	5.5
European Union	10.6	9.1	9.0	6.8	3.6	6.8	3.4
Africa	3.3	4.6	4.8	6.3	9.2	6.1	7.7
Middle East	7.0	8.4	8.4	8.7	10.7	8.4	9.4
Eurasia	3.5	4.2	4.2	4.9	5.5	4.9	5.1
Russia	3.0	3.3	3.3	3.6	3.8	3.6	3.5
Asia Pacific	24.9	35.8	36.0	37.6	40.6	35.6	33.0
China	8.8	16.8	17.0	16.1	14.2	15.6	12.6
India	3.2	5.5	5.6	7.5	10.7	6.9	8.0
Japan	4.2	2.9	2.8	2.3	2.0	2.1	1.5
Southeast Asia	4.0	5.3	5.4	6.2	7.2	5.8	5.6
International bunkers	7.1	8.2	8.5	9.6	10.4	9.2	9.6

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Table A.10: World liquids demand (mb/d)

			Current Policies		Stated Policies	
	2024	2025	2035	2050	2035	2050
Total liquids	**103.7**	**104.8**	**110.1**	**120.4**	**105.7**	**101.1**
Biofuels	2.5	2.6	3.8	5.8	3.9	4.9
Hydrogen-based fuels	-	-	0.1	0.6	0.1	0.6
Total oil	101.2	102.2	106.2	114.0	101.7	95.6
CTL, GTL and additives	0.9	1.0	1.5	1.6	1.4	1.3
Direct use of crude oil	0.9	0.8	0.3	0.2	0.3	0.1
Oil products	99.4	100.4	104.4	112.2	100.0	94.2
LPG and ethane	15.0	15.0	18.6	20.4	17.8	17.4
Naphtha	7.0	7.0	8.3	10.9	8.0	9.9
Gasoline	25.6	26.0	25.2	26.4	23.9	19.0
Kerosene	7.7	7.9	9.6	11.5	9.6	10.9
Diesel	27.8	28.0	28.3	29.0	27.1	24.4
Fuel oil	6.3	6.3	5.7	5.3	5.2	4.6
Other products	10.0	10.2	8.7	8.7	8.4	8.0
Products from NGLs	13.8	14.4	17.8	16.2	16.7	15.0
Refinery products	85.6	86.0	86.6	96.0	83.3	79.2
Refinery market share	*83%*	*82%*	*79%*	*80%*	*79%*	*78%*

Note: CTL = coal-to-liquids; GTL = gas-to-liquids; LPG = liquefied petroleum gas; NGLs = natural gas liquids.

Table A.11: Refining capacity and runs (mb/d)

	Refining capacity					Refinery runs				
		CPS		STEPS			CPS		STEPS	
	2025	2035	2050	2035	2050	2025	2035	2050	2035	2050
North America	21.8	21.9	22.2	21.6	21.4	19.2	18.8	20.2	18.3	17.5
Europe	15.4	13.6	10.3	13.1	9.3	12.3	9.4	6.5	9.1	5.8
Asia Pacific	39.1	41.1	44.6	40.2	39.0	31.1	30.8	35.6	29.7	28.3
Japan and Korea	6.7	6.2	5.8	6.0	5.2	5.2	4.6	4.3	4.4	3.5
China	19.0	19.3	18.9	19.0	18.2	15.0	13.0	13.2	12.4	10.8
India	6.0	7.4	10.2	7.0	7.2	5.4	6.9	10.0	6.5	7.0
Southeast Asia	5.5	6.1	6.6	6.1	6.1	4.1	4.9	5.9	4.9	5.4
Middle East	12.0	13.1	15.4	12.9	12.9	9.6	10.6	13.0	10.2	10.1
Russia	7.2	7.1	7.0	6.9	6.8	5.2	5.1	5.7	4.7	4.7
Africa	3.7	6.0	7.4	5.9	6.4	2.2	4.1	5.7	4.0	4.7
Brazil	2.2	2.3	2.8	2.3	2.3	1.9	2.1	2.6	2.0	2.1
World	**106.2**	**109.8**	**114.6**	**107.7**	**102.9**	**84.2**	**83.9**	**92.7**	**80.8**	**76.3**
Atlantic Basin	54.9	55.4	54.4	54.3	50.8	43.3	42.3	43.9	40.7	37.6
East of Suez	51.3	54.4	60.2	53.3	52.1	40.9	41.6	48.8	40.0	38.6

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Table A.12: Natural gas production (bcm)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**3 293**	**4 268**	**4 316**	**5 177**	**5 773**	**4 799**	**4 784**
Conventional gas	2 791	2 948	2 947	3 405	3 762	3 110	3 081
Tight gas	268	330	357	405	344	390	285
Shale gas	155	898	918	1 255	1 556	1 194	1 320
Coalbed methane	78	85	86	83	81	77	69
North America	814	1 312	1 361	1 710	1 839	1 585	1 529
Central and South America	163	161	161	199	215	175	184
Europe	341	248	241	244	185	209	156
European Union	148	37	38	49	39	38	30
Africa	210	240	242	293	396	253	291
Middle East	464	715	732	1 016	1 354	945	1 100
Eurasia	814	876	852	931	968	884	858
Asia Pacific	487	716	727	786	815	747	665
Southeast Asia	215	210	212	191	209	180	138

Table A.13: Natural gas demand (bcm)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**3 312**	**4 274**	**4 316**	**5 177**	**5 773**	**4 799**	**4 784**
North America	837	1 182	1 197	1 335	1 311	1 261	1 114
United States	678	941	954	1 081	1 038	1 024	886
Central and South America	148	159	159	194	221	181	167
Brazil	29	31	35	42	53	36	34
Europe	695	512	524	505	444	430	297
European Union	446	330	340	318	260	267	161
Africa	106	172	176	217	319	204	259
Middle East	370	601	615	776	1 003	736	866
Eurasia	578	672	663	706	715	693	674
Russia	467	535	520	538	516	531	488
Asia Pacific	574	960	964	1 378	1 656	1 238	1 331
China	110	419	428	668	768	579	583
India	64	71	69	137	223	134	193
Japan	95	89	88	95	95	83	72
Southeast Asia	149	179	178	241	297	224	263
International bunkers	4	17	18	65	104	55	76

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Table A.14: Coal production (Mtce)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**5 250**	**6 371**	**6 373**	**5 686**	**4 673**	**5 277**	**3 566**
Steam coal	4 103	5 156	5 159	4 682	3 787	4 321	2 778
Coking coal	847	991	998	874	791	841	712
Lignite and peat	300	223	216	130	96	116	76
North America	818	400	409	341	240	277	146
Central and South America	81	72	60	50	29	42	17
Europe	331	155	148	78	40	70	25
European Union	220	101	95	40	11	35	7
Africa	210	218	217	198	186	179	135
Middle East	1	3	2	4	3	3	3
Eurasia	309	420	442	404	343	372	302
Asia Pacific	3 500	5 102	5 095	4 611	3 832	4 334	2 938
Southeast Asia	325	679	646	579	555	535	469

Table A.15: Coal demand (Mtce)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**5 213**	**6 146**	**6 166**	**5 686**	**4 673**	**5 277**	**3 566**
North America	768	298	325	246	144	188	56
United States	716	275	303	234	136	181	51
Central and South America	38	39	38	40	43	36	37
Brazil	21	21	22	25	28	23	24
Europe	539	271	258	171	141	151	105
European Union	361	164	156	76	49	66	32
Africa	155	155	153	129	123	117	94
Middle East	3	7	7	11	11	10	10
Eurasia	203	270	273	237	194	219	164
Russia	151	210	210	179	134	164	115
Asia Pacific	3 507	5 106	5 110	4 853	4 018	4 555	3 100
China	2 565	3 555	3 556	3 117	2 243	2 958	1 698
India	396	790	784	974	982	892	778
Japan	165	140	138	84	51	77	45
Southeast Asia	113	356	370	479	577	459	460

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Table A.16: Electricity demand (TWh)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**18 503**	**27 690**	**28 576**	**39 177**	**52 462**	**39 042**	**51 593**
North America	4 629	5 060	5 187	6 411	7 462	6 287	7 465
United States	3 876	4 172	4 272	5 280	5 993	5 190	6 050
Central and South America	923	1 233	1 248	1 638	2 283	1 624	2 229
Brazil	451	636	640	827	1 106	813	1 059
Europe	3 563	3 507	3 556	4 566	6 007	4 566	5 930
European Union	2 571	2 457	2 496	3 198	4 272	3 181	4 157
Africa	569	778	819	1 218	2 125	1 235	2 243
Middle East	693	1 237	1 284	1 750	2 642	1 752	2 637
Eurasia	985	1 282	1 280	1 487	1 734	1 463	1 685
Russia	828	1 008	996	1 110	1 206	1 082	1 146
Asia Pacific	7 141	14 591	15 200	22 106	30 205	22 103	29 374
China	3 659	9 260	9 777	14 138	17 958	14 136	17 351
India	714	1 618	1 641	2 867	5 023	2 891	4 892
Japan	1 071	910	924	984	1 061	965	1 035
Southeast Asia	615	1 330	1 369	2 207	3 456	2 197	3 399

Table A.17: Electricity generation (TWh)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**21 544**	**31 459**	**32 402**	**44 124**	**58 548**	**43 964**	**57 800**
North America	5 233	5 586	5 749	7 107	8 241	6 970	8 236
United States	4 354	4 573	4 712	5 837	6 602	5 745	6 673
Central and South America	1 129	1 479	1 494	1 938	2 687	1 917	2 617
Brazil	516	751	756	959	1 286	939	1 227
Europe	4 119	3 998	4 058	5 143	6 505	5 138	6 598
European Union	2 955	2 794	2 847	3 595	4 607	3 578	4 619
Africa	687	968	1 014	1 477	2 492	1 491	2 607
Middle East	829	1 489	1 541	2 103	3 153	2 103	3 143
Eurasia	1 251	1 557	1 558	1 763	2 018	1 733	1 958
Russia	1 036	1 228	1 212	1 317	1 404	1 284	1 334
Asia Pacific	8 295	16 382	16 989	24 593	33 452	24 612	32 640
China	4 236	10 219	10 708	15 418	19 400	15 463	18 857
India	971	2 080	2 114	3 571	6 131	3 585	6 000
Japan	1 164	1 001	1 021	1 080	1 157	1 058	1 125
Southeast Asia	693	1 482	1 531	2 456	3 830	2 444	3 763

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Table A.18: Natural gas generation (TWh)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**4 842**	**6 904**	**6 973**	**8 944**	**10 177**	**8 050**	**7 985**
North America	1 217	2 279	2 223	2 755	2 455	2 598	1 978
United States	1 018	1 929	1 864	2 358	1 981	2 253	1 613
Central and South America	170	220	224	314	345	263	164
Brazil	36	48	58	74	119	45	43
Europe	946	700	767	669	454	440	179
European Union	589	441	483	438	286	283	84
Africa	233	405	414	550	916	502	675
Middle East	524	1 013	1 065	1 550	2 165	1 495	1 921
Eurasia	603	722	716	820	936	790	828
Russia	521	557	545	624	665	614	598
Asia Pacific	1 149	1 564	1 565	2 286	2 904	1 962	2 240
China	92	333	356	606	785	506	586
India	107	59	54	111	207	101	159
Japan	332	325	314	370	391	317	288
Southeast Asia	335	380	369	624	834	542	726

Table A.19: Coal generation (TWh)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**8 677**	**10 910**	**10 868**	**9 949**	**7 793**	**9 117**	**5 188**
North America	2 106	766	856	639	357	471	108
United States	1 994	721	813	623	353	466	108
Central and South America	41	52	50	34	23	29	18
Brazil	11	15	16	13	8	11	5
Europe	1 068	495	475	241	164	212	120
European Union	755	297	284	72	13	61	0
Africa	259	246	240	170	110	145	67
Middle East	0	4	4	8	8	6	6
Eurasia	235	303	312	286	233	253	195
Russia	166	225	230	206	162	176	133
Asia Pacific	4 968	9 044	8 930	8 571	6 899	8 002	4 674
China	3 263	6 010	5 926	5 314	3 858	4 990	2 309
India	658	1 504	1 456	1 796	1 585	1 656	1 256
Japan	317	290	295	139	47	125	40
Southeast Asia	192	716	739	983	1 199	956	939

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Table A.20: Nuclear generation (TWh)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**2 756**	**2 819**	**2 856**	**4 164**	**6 107**	**4 203**	**6 439**
North America	935	913	914	1 039	1 859	1 053	1 892
United States	839	816	819	908	1 700	928	1 737
Central and South America	22	27	27	52	63	52	63
Brazil	15	16	16	39	43	39	43
Europe	1 032	779	774	914	1 054	929	1 128
European Union	854	650	653	725	834	735	880
Africa	12	8	10	68	85	67	101
Middle East	0	45	47	95	124	100	145
Eurasia	173	218	224	256	345	262	345
Russia	170	216	221	246	294	246	294
Asia Pacific	582	827	859	1 740	2 577	1 739	2 764
China	74	451	485	1 078	1 409	1 081	1 503
India	26	57	56	164	502	168	581
Japan	288	93	104	185	212	185	202
Southeast Asia	0	0	0	9	123	9	169

Table A.21: Renewables generation (TWh)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**4 209**	**9 932**	**10 830**	**20 591**	**34 111**	**22 174**	**37 919**
North America	856	1 534	1 668	2 621	3 536	2 810	4 236
United States	441	1 049	1 163	1 911	2 541	2 073	3 200
Central and South America	752	1 096	1 114	1 480	2 222	1 517	2 340
Brazil	437	662	657	828	1 113	840	1 133
Europe	954	1 935	1 957	3 276	4 802	3 525	5 155
European Union	653	1 335	1 360	2 328	3 450	2 477	3 647
Africa	116	235	275	619	1 330	711	1 723
Middle East	18	61	67	326	775	410	1 045
Eurasia	226	299	292	396	498	422	584
Russia	167	217	204	234	278	241	304
Asia Pacific	1 287	4 773	5 456	11 872	20 948	12 779	22 835
China	782	3 407	3 923	8 399	13 318	8 873	14 454
India	161	443	532	1 493	3 833	1 653	4 003
Japan	106	230	246	339	449	385	538
Southeast Asia	105	370	404	828	1 667	932	1 928

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Table A.22: Solar PV generation (TWh)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**33**	**2 089**	**2 723**	**8 347**	**15 150**	**9 381**	**17 764**
North America	3	306	410	989	1 403	1 138	2 048
United States	3	275	374	882	1 215	1 024	1 841
Central and South America	0	105	122	309	456	339	509
Brazil	0	71	81	199	245	222	275
Europe	23	375	465	984	1 325	1 086	1 488
European Union	22	304	373	790	1 052	858	1 149
Africa	0	20	31	226	526	286	727
Middle East	0	32	38	231	518	296	752
Eurasia	0	10	16	43	59	51	88
Russia	0	3	3	6	9	7	15
Asia Pacific	6	1 241	1 641	5 566	10 864	6 185	12 152
China	1	839	1 174	3 973	7 069	4 294	7 925
India	0	148	184	852	2 317	979	2 438
Japan	4	98	111	147	196	183	263
Southeast Asia	0	48	53	247	545	298	638

Table A.23: Wind generation (TWh)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**342**	**2 528**	**2 724**	**5 822**	**10 398**	**6 328**	**11 358**
North America	105	525	542	821	1 163	844	1 215
United States	95	457	467	671	860	692	893
Central and South America	3	150	161	264	547	289	624
Brazil	2	108	115	172	337	183	367
Europe	154	630	624	1 298	2 216	1 448	2 418
European Union	140	490	478	978	1 696	1 059	1 791
Africa	2	32	34	103	244	123	340
Middle East	0	5	4	58	150	75	181
Eurasia	0	10	12	56	111	70	153
Russia	0	5	4	13	39	16	54
Asia Pacific	77	1 177	1 347	3 221	5 968	3 478	6 428
China	45	997	1 128	2 550	4 052	2 694	4 287
India	20	96	123	304	973	338	1 023
Japan	4	12	13	45	76	53	94
Southeast Asia	0	18	20	137	401	172	500

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Table A.24: Curtailment of variable renewables

	Current Policies Curtailment (TWh)			Share of variable renewables curtailed			Stated Policies Curtailment (TWh)			Share of variable renewables curtailed		
	2030	2035	2050	2030	2035	2050	2030	2035	2050	2030	2035	2050
World	**275**	**876**	**3 986**	**3%**	**6%**	**13%**	**185**	**644**	**3 907**	**2%**	**4%**	**12%**
North America	33	75	160	2%	4%	6%	26	63	271	2%	3%	8%
United States	32	69	139	3%	4%	6%	24	58	253	2%	3%	8%
Central and South America	12	27	92	3%	5%	8%	10	24	85	2%	4%	7%
Brazil	7	15	47	2%	4%	8%	4	10	42	1%	2%	6%
Europe	99	250	650	5%	10%	16%	60	195	580	3%	7%	13%
European Union	76	201	540	5%	10%	16%	41	123	422	3%	6%	13%
Africa	4	21	80	2%	6%	9%	5	26	118	2%	6%	10%
Middle East	1	4	15	1%	1%	2%	1	5	30	1%	1%	3%
Eurasia	0	1	2	0%	1%	1%	0	1	2	0%	1%	1%
Russia	0	0	0	0%	0%	0%	0	0	0	0%	0%	0%
Asia Pacific	125	499	2 987	2%	5%	15%	83	330	2 819	1%	3%	13%
China	89	390	2 097	2%	6%	16%	40	218	2 032	1%	3%	14%
India	10	49	683	2%	4%	17%	7	39	525	1%	3%	13%
Japan	2	4	13	1%	2%	5%	2	7	22	1%	3%	6%
Southeast Asia	3	12	65	1%	3%	6%	3	12	68	1%	2%	6%

Table A.25: Total final consumption (EJ)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**378.9**	**459.4**	**466.1**	**533.3**	**610.8**	**514.4**	**548.2**
North America	76.6	79.6	81.1	87.3	93.5	84.6	81.3
United States	63.8	65.9	67.2	72.8	77.7	70.4	67.1
Central and South America	19.2	22.1	22.4	26.8	33.9	25.8	30.4
Brazil	9.1	11.0	11.2	13.0	16.2	12.5	14.4
Europe	63.0	56.0	56.2	55.1	52.7	53.8	47.8
European Union	46.0	40.3	40.3	38.0	34.1	37.3	31.4
Africa	17.8	24.2	24.9	31.0	43.0	29.7	37.9
Middle East	18.4	25.4	25.6	31.4	41.3	30.4	37.2
Eurasia	25.3	30.4	30.2	33.2	35.0	32.7	33.0
Russia	20.8	24.6	24.2	25.3	24.8	24.9	23.5
Asia Pacific	143.4	203.8	207.2	245.2	282.7	235.1	254.2
China	76.0	116.3	118.5	133.1	138.0	128.5	126.8
India	18.8	32.5	33.4	47.5	66.2	44.5	57.7
Japan	14.2	11.1	11.1	10.4	10.1	9.9	8.7
Southeast Asia	14.4	21.4	22.0	28.9	37.4	27.8	33.3

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Table A.26: Industry consumption (EJ)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**141.7**	**175.2**	**177.4**	**205.6**	**230.6**	**197.5**	**210.8**
North America	17.7	19.6	19.8	21.9	23.8	21.0	21.6
United States	14.0	15.4	15.5	17.1	18.4	16.5	16.7
Central and South America	7.3	7.4	7.5	8.6	10.1	8.4	9.6
Brazil	4.0	4.2	4.2	4.8	5.6	4.7	5.4
Europe	19.6	16.4	16.1	16.9	17.6	16.2	15.8
European Union	14.3	12.2	12.0	12.1	12.0	11.6	10.8
Africa	4.0	4.7	4.9	6.2	8.7	6.1	8.1
Middle East	7.5	9.8	9.8	11.7	14.8	11.3	13.5
Eurasia	8.4	10.0	10.1	11.2	11.5	11.0	10.9
Russia	6.8	8.5	8.4	9.1	8.8	8.9	8.3
Asia Pacific	77.3	107.2	109.3	129.0	144.0	123.5	131.2
China	49.0	68.9	70.2	78.1	77.9	74.9	71.3
India	7.7	15.0	15.8	23.4	33.8	22.1	30.1
Japan	6.1	4.7	4.6	4.4	4.3	4.2	3.9
Southeast Asia	5.8	9.3	9.5	12.5	16.0	12.1	14.8

Table A.27: Transport consumption (EJ)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**101.8**	**127.0**	**128.9**	**143.8**	**166.9**	**139.9**	**146.2**
North America	29.6	30.9	31.0	32.4	34.6	31.3	27.5
United States	25.0	26.2	26.1	27.6	29.7	26.6	23.2
Central and South America	6.1	7.9	8.2	10.2	13.9	9.8	12.2
Brazil	2.9	4.0	4.2	5.0	6.5	4.8	5.5
Europe	15.6	16.4	16.7	14.4	11.0	14.5	10.6
European Union	11.7	11.9	12.0	9.8	6.4	10.1	6.6
Africa	3.7	5.7	5.9	8.1	12.4	7.8	10.8
Middle East	4.9	6.4	6.4	7.7	10.6	7.6	9.8
Eurasia	4.7	5.7	5.7	6.5	7.5	6.4	7.0
Russia	4.0	4.5	4.4	4.6	4.9	4.5	4.5
Asia Pacific	22.0	36.0	36.6	41.3	48.0	40.0	41.9
China	8.2	16.3	16.5	15.9	14.3	15.8	14.2
India	2.7	5.6	5.8	9.0	13.6	8.5	11.1
Japan	3.3	2.6	2.6	2.4	2.2	2.2	1.7
Southeast Asia	3.7	6.6	6.8	8.4	10.2	8.1	8.6

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Table A.28: Buildings consumption (EJ)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**113.3**	**129.0**	**131.1**	**150.0**	**176.0**	**143.9**	**156.3**
North America	23.7	23.9	25.1	27.3	29.2	26.5	26.5
United States	20.5	20.4	21.5	23.6	25.0	22.9	22.8
Central and South America	4.4	5.3	5.3	6.2	7.8	5.8	6.8
Brazil	1.4	1.9	1.9	2.2	3.0	2.0	2.5
Europe	24.3	20.0	20.1	20.5	20.8	19.9	18.4
European Union	17.6	13.9	14.0	13.9	13.6	13.5	12.1
Africa	9.3	12.8	13.2	15.4	20.0	14.5	17.1
Middle East	5.1	7.7	7.8	9.6	12.8	9.4	11.4
Eurasia	9.6	11.8	11.6	12.3	12.5	12.2	11.9
Russia	7.5	9.0	8.8	8.7	8.0	8.6	7.7
Asia Pacific	36.9	47.4	48.0	58.6	72.9	55.6	64.2
China	15.6	23.4	23.8	29.7	36.7	28.5	32.8
India	7.0	9.4	9.4	11.5	13.6	10.3	11.6
Japan	4.3	3.5	3.5	3.3	3.3	3.2	2.8
Southeast Asia	3.9	4.5	4.6	6.5	9.6	6.2	8.3

Table A.29: Electrification rate

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**19%**	**23%**	**23%**	**28%**	**33%**	**29%**	**36%**
North America	23%	25%	25%	29%	31%	29%	36%
United States	24%	24%	25%	28%	30%	29%	36%
Central and South America	19%	21%	21%	23%	25%	23%	27%
Brazil	19%	21%	21%	23%	25%	24%	27%
Europe	22%	24%	24%	31%	42%	32%	45%
European Union	22%	23%	24%	32%	46%	32%	49%
Africa	12%	12%	12%	15%	18%	15%	21%
Middle East	16%	20%	20%	22%	25%	23%	27%
Eurasia	14%	15%	15%	16%	18%	17%	19%
Russia	15%	15%	15%	16%	18%	16%	19%
Asia Pacific	19%	28%	29%	35%	41%	37%	45%
China	18%	31%	32%	42%	51%	43%	53%
India	15%	19%	19%	23%	29%	25%	33%
Japan	30%	31%	32%	36%	41%	38%	46%
Southeast Asia	17%	25%	26%	31%	37%	32%	41%

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Table A.30: Useful energy demand (EJ)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**197.3**	**266.9**	**273.3**	**344.2**	**449.2**	**341.7**	**439.2**
North America	41.8	47.9	49.2	54.9	63.6	54.5	61.9
United States	35.8	40.6	41.7	46.4	52.9	46.0	51.5
Central and South America	9.4	12.1	12.3	16.4	23.3	16.3	22.8
Brazil	4.7	6.3	6.5	8.6	12.1	8.5	11.7
Europe	37.3	35.3	35.7	38.8	41.8	38.6	40.7
European Union	27.2	25.2	25.6	26.6	27.2	26.5	26.6
Africa	5.6	8.4	8.8	12.9	21.8	12.9	22.0
Middle East	9.5	14.7	15.1	19.6	27.7	19.4	26.6
Eurasia	14.5	18.8	18.8	21.7	23.8	21.6	23.5
Russia	11.5	14.9	14.7	16.2	16.5	16.1	16.2
Asia Pacific	75.5	124.4	128.0	172.4	236.9	170.8	231.3
China	43.7	76.9	79.3	100.6	122.1	99.8	119.4
India	7.9	17.1	17.6	31.1	56.1	30.5	54.1
Japan	8.6	7.9	8.0	8.0	8.3	7.9	8.0
Southeast Asia	5.8	10.9	11.3	17.9	28.9	17.9	28.6

Table A.31: Useful energy demand by fuel and sector (EJ)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**197.3**	**266.9**	**273.3**	**344.2**	**449.2**	**341.7**	**439.2**
Electricity	54.6	97.5	101.5	153.9	238.8	156.6	245.9
Bioenergy and waste	8.1	11.2	11.5	13.6	16.7	13.6	17.2
Coal	35.8	31.5	31.1	31.5	31.9	29.7	27.6
Natural gas	38.0	48.6	49.6	59.6	68.4	57.7	62.7
Oil	48.6	58.2	59.0	61.3	66.0	59.5	57.5
Other	12.2	19.9	20.6	24.3	27.5	24.7	28.3
Buildings	74.7	109.3	113.1	151.9	220.3	151.5	215.4
Industry	86.0	105.7	107.2	127.3	148.1	125.6	144.9
Transport	31.6	44.7	45.7	55.8	69.4	55.4	67.8
Agriculture	5.0	7.2	7.4	9.2	11.5	9.1	11.1

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Table A.32: Hydrogen demand (PJ)

			Current Policies		Stated Policies	
	2024	2025	2035	2050	2035	2050
World	**11 974**	**12 256**	**14 744**	**17 759**	**15 014**	**18 267**
North America	1 953	2 011	2 271	2 626	2 269	2 693
United States	1 619	1 658	1 816	2 067	1 836	2 168
Central and South America	349	353	494	637	497	652
Brazil	46	53	100	119	102	126
Europe	918	895	959	1 524	996	1 596
European Union	740	710	752	1 314	787	1 376
Africa	381	373	519	862	508	831
Middle East	1 696	1 687	2 163	2 786	2 267	3 092
Eurasia	829	841	917	886	919	898
Russia	747	758	812	762	814	774
Asia Pacific	5 848	6 097	7 575	8 567	7 730	8 683
China	3 510	3 736	4 443	4 629	4 489	4 665
India	1 152	1 173	1 653	2 059	1 587	1 819
Japan	222	214	218	202	227	242
Southeast Asia	441	458	622	751	633	794
International bunkers	-	-	1	3	16	75

Table A.33: Low-emissions hydrogen balance (Mt H_2 equivalent)

		Current Policies		Stated Policies		Net Zero Emissions by 2050	
	2025	2035	2050	2035	2050	2035	2050
Low-emissions hydrogen production	0.9	10	31	12	37	117	354
Water electrolysis	0.2	7	26	8	28	89	284
Fossil fuels with CCUS	0.6	3	5	4	8	28	68
Bioenergy and other	0.1	0	0	0	0	0	1
Transformation of hydrogen	0.3	4	19	6	23	75	193
To power generation	-	0	1	2	3	19	31
To hydrogen-based fuels	0.0	3	17	3	17	46	155
In oil refining	0.3	1	2	1	2	8	5
To biofuels	0.0	0	0	0	1	3	3
Hydrogen demand for end-use sectors	0.6	4	9	6	14	39	153
Low-emissions hydrogen-based fuels	-	3	16	3	17	44	147
Total final consumption	-	2	14	2	15	33	133
Power generation	-	1	2	1	3	11	14
Trade	0.0	5	18	5	20	27	65
Trade as share of demand	0%	57%	64%	44%	55%	23%	19%

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Table A.34: Total CO_2 emissions* (Mt CO_2)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**32 804**	**38 493**	**38 696**	**38 729**	**38 047**	**36 219**	**30 463**
North America	6 478	5 618	5 751	5 731	5 388	5 304	4 164
United States	5 468	4 538	4 666	4 698	4 323	4 335	3 286
Central and South America	1 150	1 214	1 214	1 389	1 659	1 317	1 342
Brazil	411	458	464	516	620	477	485
Europe	4 722	3 529	3 515	2 806	2 096	2 571	1 574
European Union	3 316	2 387	2 374	1 733	1 072	1 593	772
Africa	1 176	1 478	1 519	1 724	2 326	1 623	1 921
Middle East	1 641	2 334	2 354	2 538	3 134	2 412	2 682
Eurasia	2 125	2 477	2 485	2 511	2 497	2 419	2 268
Russia	1 669	1 914	1 903	1 861	1 732	1 791	1 579
Asia Pacific	14 387	20 561	20 506	20 419	19 145	19 039	14 889
China	8 771	12 698	12 630	11 385	8 918	10 696	6 815
India	1 668	3 149	3 153	4 097	4 810	3 768	3 759
Japan	1 187	972	959	726	581	664	452
Southeast Asia	1 129	2 032	2 078	2 600	3 098	2 463	2 520

*Includes industrial process and flaring emissions.

Table A.35: Electricity and heat sectors CO_2 emissions (Mt CO_2)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**12 507**	**15 763**	**15 840**	**14 633**	**12 437**	**13 394**	**9 125**
North America	2 596	1 734	1 800	1 695	1 277	1 469	861
United States	2 346	1 498	1 564	1 510	1 101	1 320	727
Central and South America	235	223	219	213	189	188	112
Brazil	46	52	58	52	58	39	28
Europe	1 732	947	941	598	416	474	243
European Union	1 188	590	586	302	168	224	57
Africa	420	488	488	436	488	389	344
Middle East	548	817	838	799	951	723	776
Eurasia	1 034	1 149	1 162	1 093	989	1 046	902
Russia	892	922	922	873	757	837	694
Asia Pacific	5 942	10 405	10 392	9 798	8 126	9 105	5 887
China	3 509	6 691	6 715	5 957	4 446	5 595	3 022
India	785	1 576	1 524	1 738	1 508	1 600	1 191
Japan	499	444	445	274	175	241	134
Southeast Asia	405	934	956	1 255	1 519	1 189	1 216

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Table A.36: Total final consumption CO_2 emissions* (Mt CO_2)

				Current Policies		Stated Policies	
	2010	2024	2025	2035	2050	2035	2050
World	**18 600**	**20 820**	**20 958**	**22 033**	**23 444**	**20 887**	**19 541**
North America	3 465	3 418	3 479	3 496	3 538	3 344	2 826
United States	2 862	2 778	2 832	2 860	2 876	2 729	2 271
Central and South America	804	889	902	1 069	1 356	1 016	1 139
Brazil	342	386	395	446	545	423	446
Europe	2 814	2 439	2 435	2 097	1 590	1 992	1 251
European Union	2 014	1 698	1 690	1 353	841	1 297	660
Africa	568	811	846	1 115	1 659	1 073	1 429
Middle East	930	1 209	1 211	1 416	1 789	1 366	1 571
Eurasia	898	1 201	1 195	1 292	1 371	1 265	1 262
Russia	654	895	882	893	874	876	811
Asia Pacific	7 995	9 569	9 540	9 939	10 338	9 295	8 442
China	4 999	5 683	5 595	5 012	4 081	4 714	3 457
India	848	1 491	1 546	2 255	3 163	2 072	2 468
Japan	660	510	496	438	394	410	309
Southeast Asia	647	1 003	1 030	1 262	1 505	1 191	1 246

* Includes industrial process emissions.

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Design of the scenarios

This annex provides an overview of the design of the *World Energy Outlook 2026 (WEO-2026)* scenarios and a summary of key underlying assumptions. The following sections and tables outline assumptions related to population, gross domestic product, fossil fuel resources, electricity generation technology costs, other key technology costs, CO_2 prices, and policies. Each table indicates which scenarios the assumptions apply to; unless otherwise specified, the assumptions apply to all scenarios. The annex focuses on scenario designs: it therefore excludes cases developed throughout the report.

The *Outlook* puts forward two exploratory scenarios, which proceed from different starting conditions and see where they lead the energy system. These scenarios do not have a fixed view on the end point. For example, they do not assume that longer-term goals, such as national or regional net zero targets, are met. We also include one normative scenario – the Net Zero Emissions by 2050 Scenario – that works towards pre-defined goals and maps out ways to realise them.

- The **Current Policies Scenario (CPS)** is an exploratory scenario in which no change in energy-related policies is assumed beyond what was firmly in place as of August 2026, and no further action is assumed on time-limited policies once they expire. Given the time it takes to formally adopt new legislation and regulation, this scenario does not incorporate many policy responses to the Middle East conflict. It does, however, capture some near-term responses and behavioural changes that could have longer-term implications, such as the observed change in consumer purchasing behaviour for electric vehicles and rooftop solar and the easing of operational restrictions on coal-fired power in some countries. The CPS offers a generally cautious perspective on the speed at which new energy technologies are deployed and integrated into the energy system, and it tends to project slower growth in the adoption of new technologies than has been seen in recent years or is projected in the Stated Policies Scenario.

- The **Stated Policies Scenario (STEPS)** builds on a broader reading of the policy landscape than the CPS. Alongside policies already in place, it takes account of concrete policy proposals and official strategy documents that indicate the direction in which governments intend to move. This includes measures developed in response to the Middle East conflict as of August 2026, such as new plans and targets to expand renewable and clean electricity generation (as in Indonesia, Korea and Thailand); new initiatives to support transport electrification (as in the European Union and Indonesia); additional support for energy efficiency improvements (as in Canada, China and Türkiye); and measures to increase the use of biofuels (as in Brazil). In addition, the STEPS offers a more dynamic perspective on energy technology and market trends than the CPS, allowing for a more rapid introduction of new energy technologies.

- The **Net Zero Emissions by 2050 (NZE) Scenario** is the only normative scenario in this year's *Outlook*. It is specifically designed to achieve an ambitious reduction in energy-

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related emissions. It maps out a way for the global energy system to achieve net zero CO_2 emissions by 2050 and is consistent with a long-term goal of limiting the rise in global average temperatures to 1.5 °C (with a 50% probability). In the light of persistently high emissions in recent years, warming in this scenario peaks just below 1.7 °C and exceeds 1.5 °C for several decades before returning below 1.5 °C by 2100. This requires a very rapid transformation of the energy sector along with the widespread deployment of CO_2 removal technologies.

This year's WEO also includes two new cases – the Additional Response Case and the Low Hormuz Case – that expand our analysis of the potential implications of the Middle East conflict beyond those captured in the exploratory scenarios.

- The **Additional Response Case (ARC)** goes further than the CPS and the STEPS in accounting for possible responses to the disruptions in energy markets in 2026. Most countries have been focused on managing the immediate impacts of the conflict in the Middle East and have not yet had time to formulate longer-term policy responses that would qualify for inclusion in the CPS or the STEPS. Nonetheless, there are preliminary indications in speeches and other public statements of how governments' longer-term policy priorities could evolve in response to the crisis. The ARC explores what would happen if these potential changes were turned into actionable policy proposals and then implemented. It therefore examines how a more far-reaching response to heightened energy security concerns could reshape the energy system over time. This brings into play a range of additional demand- and supply-side measures, which typically put greater emphasis on efforts to diversify fuel suppliers and import routes; strengthened incentives or frameworks to develop domestically available resources and improve energy efficiency; and a stronger push for electrification of end-use consumption, for instance for transport. Insofar as these measures affect demand for imported oil and natural gas, the response from most exporters is to use more of their production at home, so their domestic energy mix tends more towards what is seen in the CPS. However, this varies by country.
- While the ARC looks at a range of possible additional responses to heightened energy security concerns, the **Low Hormuz Case (LHC)** addresses a specific issue: whether and how the energy world could manage without the transit of energy supplies through the Strait of Hormuz.

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B.1 Population

Table B.1 ▷ Population assumptions by region

	Compound average annual growth rate (%)			Population (million)			Urbanisation (share of population, %)		
	2015-25	2025-35	2025-50	2025	2035	2050	2025	2035	2050
North America	0.7	0.5	0.4	517	544	572	80	82	87
United States	0.5	0.4	0.4	342	357	374	80	82	87
C & S America	0.7	0.5	0.3	531	559	577	82	84	87
Brazil	0.5	0.3	0.1	213	218	217	88	90	91
Europe	0.2	-0.1	-0.1	697	691	671	77	79	83
European Union	0.1	-0.2	-0.3	449	441	422	75	77	81
Africa	2.4	2.1	1.9	1 548	1 908	2 464	46	51	60
Middle East	1.9	1.5	1.3	286	332	391	73	74	78
Eurasia	0.5	0.3	0.4	243	252	266	65	66	68
Russia	-0.1	-0.3	-0.2	143	139	135	75	77	81
Asia Pacific	0.7	0.4	0.3	4 369	4 557	4 677	52	55	63
China	0.2	-0.3	-0.5	1 413	1 371	1 257	67	73	90
India	1.0	0.8	0.6	1 464	1 579	1 680	36	39	43
Japan	-0.3	-0.6	-0.6	123	116	105	92	94	96
Southeast Asia	0.9	0.6	0.4	699	740	773	54	60	68
World	**1.0**	**0.8**	**0.6**	**8 192**	**8 843**	**9 618**	**58**	**61**	**67**

Notes: C & S America = Central and South America. See Annex C for composition of regional groupings.

Sources: OECD (2026); UN DESA (2018; 2024); World Bank (2026a); IEA databases and analysis.

- Population is a major determinant of many of the trends in the *Outlook*. We use the medium variant of the United Nations projections as the basis for population growth in all scenarios, but this is naturally subject to a degree of uncertainty.
- On average, the rate of population growth is assumed to slow over time, but the global population approaches 9.6 billion by 2050 (Table B.1).
- About 65% of the increase over the projection period to 2050 is in Africa and more than 20% is in the Asia Pacific region.
- The share of the world's population living in towns and cities has been rising steadily, a trend that is projected to continue over the period to 2050. In aggregate, this means that virtually all of the 1.4 billion increase in global population over the period is added to cities and towns.

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B.2 Gross domestic product

Table B.2 ▷ GDP average growth assumptions by region

	Compound average annual growth rate			
	2015-25	2025-35	2035-50	2025-50
North America	2.3%	1.9%	1.8%	1.9%
United States	2.4%	2.0%	1.8%	1.9%
Central and South America	1.2%	2.6%	2.0%	2.2%
Brazil	1.4%	2.3%	2.1%	2.2%
Europe	1.9%	1.6%	1.2%	1.4%
European Union	1.7%	1.3%	0.9%	1.0%
Africa	2.8%	4.3%	4.0%	4.1%
South Africa	0.6%	1.7%	2.3%	2.0%
Middle East	2.3%	3.0%	2.7%	2.8%
Eurasia	2.3%	1.8%	1.6%	1.7%
Russia	1.8%	0.9%	0.5%	0.7%
Asia Pacific	4.5%	3.9%	2.7%	3.2%
China	5.5%	3.5%	2.2%	2.7%
India	5.8%	6.2%	3.9%	4.8%
Japan	0.5%	0.6%	0.7%	0.7%
Southeast Asia	4.0%	4.4%	3.0%	3.6%
World	**3.1%**	**3.0%**	**2.4%**	**2.6%**

Note: GDP = gross domestic product. Calculated based on GDP expressed in year-2025 US dollars in purchasing power parity terms. See Annex C for composition of regional groupings.

Sources: IEA analysis based on IMF (2026) and Oxford Economics (2026).

- The global economy is assumed to grow by 2.6% on average annually to 2050 across all scenarios. Out to 2030, our gross domestic product (GDP) assumptions at a country and regional level are based on the International Monetary Fund (IMF) World Economic Outlook, with global GDP projected to grow by 3.2% annually over this period (IMF, 2026).
- After 2030, GDP growth assumptions are based on forecasts from Oxford Economics (2026) and the application of the Solow growth model (World Bank, 2022). The Solow model estimates future GDP on a country and regional basis by accounting for labour supply, capital stock and total factor productivity (TFP). TFP growth reflects catch-up dynamics in lower-income countries and convergence towards advanced economy levels. Economic assumptions are held constant across the various scenarios to facilitate comparisons between them, although we recognise that decisions taken by policy makers in the energy sector have broader economic implications.

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B.3 Fossil fuel resources

Table B.3 ▷ Remaining technically recoverable fossil fuel resources, 2025

Oil (billion barrels)	Proven reserves	Resources	Conventional crude oil	Tight oil	NGLs	EHOB	Kerogen oil
North America	222	2 399	229	230	146	794	1 000
Central and South America	297	845	245	57	49	492	3
Europe	14	108	53	19	27	3	6
Africa	125	443	304	54	82	2	-
Middle East	902	1 127	849	29	205	14	30
Eurasia	146	935	223	85	57	552	18
Asia Pacific	52	267	113	72	63	3	16
World	**1 758**	**6 124**	**2 016**	**545**	**630**	**1 860**	**1 073**

Natural gas (trillion cubic metres)	Proven reserves	Resources	Conventional gas	Tight gas	Shale gas	Coalbed methane
North America	22	143	49	9	78	7
Central and South America	9	84	28	15	41	-
Europe	5	45	18	5	18	5
Africa	19	100	50	10	40	0
Middle East	84	119	99	9	11	-
Eurasia	69	165	127	11	10	17
Asia Pacific	19	136	42	21	53	20
World	**227**	**792**	**413**	**80**	**250**	**49**

Coal (billion tonnes)	Proven reserves	Resources	Coking coal	Steam coal	Lignite
North America	257	8 387	1 032	5 836	1 519
Central and South America	14	60	3	32	25
Europe	137	978	165	413	400
Africa	15	344	43	299	2
Middle East	1	41	36	5	-
Eurasia	191	2 019	394	994	632
Asia Pacific	460	8 852	1 726	5 869	1 256
World	**1 074**	**20 681**	**3 399**	**13 449**	**3 834**

Notes: NGLs = natural gas liquids; EHOB = extra-heavy oil and bitumen. The breakdown of coal resources by type is an IEA estimate. World coal resources exclude Antarctica and are total proven reserves at end-2024.

Sources: BGR (2025); CEDIGAZ (2026); Energy Institute (2026); OGJ (2025); US EIA (2026); USGS (2012a; 2012b); IEA databases and analysis.

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- The *World Energy Outlook* supply modelling relies on estimates of the remaining technically recoverable resources, rather than the (often more widely quoted) numbers for proven reserves. Resource estimates are subject to considerable uncertainty, as is the distinction in the analysis between conventional and unconventional resource types.
- Overall, the remaining technically recoverable resources of fossil fuels are similar to those in the *World Energy Outlook 2025*. Resources of all fuels are sufficient to meet projected global energy demand growth to 2050 in all scenarios. Remaining technically recoverable resources of US tight oil, crude plus condensate, total around 210 billion barrels.
- The gradual depletion of resources, at a pace that varies by scenario, means that operators have to develop more difficult and complex reservoirs. This tends to push up production costs over time, although this effect is offset by the assumed continuous adoption of new, more efficient production technologies and practices.
- World coal resources are made up of various types: around 80% is steam and coking coal, and the remainder is lignite. Close to 85% of coal resources are located in Asia Pacific and North America.

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B.4 Electricity generation technology costs

- All cost components, levelised cost of electricity (LCOE) and value-adjusted LCOE (VALCOE) figures are expressed in year-2025 US dollars and rounded.
- Major contributors to the LCOE include: overnight capital costs; capacity factor that describes the average output over the year relative to the maximum rated capacity (typical values provided); cost of fuel inputs; plus operation and maintenance. Economic lifetime assumptions are 25 years for next-generation geothermal, solar photovoltaics (PV), and onshore and offshore wind.
- Weighted average cost of capital (WACC) assumptions reflect market data and survey information provided through the *Cost of Capital Observatory* (IEA, 2025); updated analysis for utility-scale solar PV in the *World Energy Outlook 2020* (IEA, 2020), with a range of 4-7%; and analysis for offshore wind from the *Offshore Wind Outlook 2019* (IEA, 2019), with a range of 5-8%. Onshore wind is assumed to have the same WACC as utility-scale solar PV. A standard WACC was assumed for nuclear, coal-fired and gas-fired power plants (7-9% based on the stage of economic development and sources of financing).
- The VALCOE incorporates information on both costs and the value provided to the system. Building on the LCOE, the VALCOE adds estimates of energy, capacity and flexibility value to provide a more complete metric of competitiveness for power generation technologies. Lower values for VALCOE indicate improved competitiveness.
- Fuel, CO_2, and operation and maintenance costs reflect the average over the ten years following the indicated date in the projections (and therefore vary by scenario in 2025).
- Solar PV and wind costs do not include the cost of energy storage technologies, such as utility-scale batteries.
- Capital costs for nuclear power represent the “nth-of-a-kind” costs for new reactor designs, with substantial cost reductions from the first-of-a-kind projects. The estimates have been updated following a comprehensive review of recent cost data covering nearly all new reactors completed between 2013 and 2025.
- Electricity generation costs reflect total electricity supply costs, including grids, per unit of electricity generation.
- Abbreviations and acronyms used in the tables include: kW = kilowatt; MWh = megawatt-hour; O&M = operation and maintenance; LCOE = levelised cost of electricity; VALCOE = value-adjusted LCOE; CCGT = combined-cycle gas turbine; PV = photovoltaics; n.a. = not applicable.

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Table B.4a ▷ Technology costs in selected regions in the Current Policies Scenario

	Capital costs (USD/kW)			Capacity factor (%)			Fuel, CO_2, O&M (USD/MWh)			LCOE (USD/MWh)			VALCOE (USD/MWh)		
	2025	2035	2050	2025	2035	2050	2025	2035	2050	2025	2035	2050	2025	2035	2050
United States															
Nuclear	10 000	9 100	7 700	90	90	90	30	30	30	155	145	125	155	145	125
Coal	2 100	2 100	2 100	50	40	35	30	30	30	90	105	120	90	100	115
Gas CCGT	1 500	1 500	1 500	60	55	50	40	45	45	70	80	85	70	75	80
Geothermal*	15 000	9 000	6 600	75	75	80	50	25	20	330	195	135	330	195	135
Solar PV	1 180	820	690	20	23	23	10	10	10	55	40	30	65	55	50
Wind onshore	1 670	1 590	1 550	42	44	44	10	10	10	45	40	40	50	45	45
Wind offshore	5 620	4 020	3 220	41	46	49	45	30	25	175	110	85	180	115	90
Electricity generation costs										75	85	95			
European Union															
Nuclear	10 000	8 800	7 500	80	85	85	35	35	35	175	155	135	170	150	130
Coal	2 000	2 000	2 000	30	30	n.a.	115	120	n.a.	215	220	n.a.	190	180	n.a.
Gas CCGT	1 500	1 500	1 500	15	15	15	125	120	125	240	245	245	185	190	165
Geothermal*	21 630	18 130	16 730	75	75	80	55	45	45	455	380	330	450	370	320
Solar PV	780	540	450	13	13	13	10	10	10	55	40	35	65	65	70
Wind onshore	1 730	1 640	1 590	29	30	30	15	15	15	65	60	55	75	75	75
Wind offshore	3 760	2 800	2 240	50	54	55	20	15	10	85	60	45	85	70	60
Electricity generation costs										130	115	105			
China															
Nuclear	2 600	2 500	2 400	85	80	80	25	25	25	65	65	65	65	65	65
Coal	800	800	800	50	40	40	40	40	35	60	65	65	55	55	50
Gas CCGT	820	860	860	25	20	20	80	80	85	120	130	135	110	110	105
Geothermal*	16 050	11 050	9 050	75	75	80	55	30	25	320	215	165	320	215	165
Solar PV	530	360	290	12	12	12	10	10	10	45	30	25	65	55	55
Wind onshore	790	750	720	23	23	24	10	10	10	40	35	35	45	45	60
Wind offshore	1 540	1 160	920	30	32	32	15	10	10	65	45	35	70	55	55
Electricity generation costs										70	70	60			
India															
Nuclear	3 300	3 200	3 000	75	80	80	30	30	30	85	80	75	85	80	75
Coal	1 200	1 200	1 200	70	75	75	40	45	45	60	65	65	60	65	60
Gas CCGT	1 100	1 100	1 100	30	40	45	55	60	60	100	95	90	95	85	75
Geothermal*	19 500	15 000	13 200	75	75	80	75	55	45	400	305	250	400	305	250
Solar PV	540	360	290	20	20	21	5	5	5	35	20	20	40	35	55
Wind onshore	1 170	1 110	1 060	27	29	30	15	10	10	55	50	45	60	55	55
Wind offshore	2 860	2 140	1 660	34	38	39	25	20	15	120	85	65	120	90	75
Electricity generation costs										70	70	60			

*Next-generation geothermal.

Sources: IEA analysis; IRENA (2026).

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Table B.4b ▷ Technology costs in selected regions in the Stated Policies Scenario

	Capital costs (USD/kW)			Capacity factor (%)			Fuel, CO_2, O&M (USD/MWh)			LCOE (USD/MWh)			VALCOE (USD/MWh)		
	2025	2035	2050	2025	2035	2050	2025	2035	2050	2025	2035	2050	2025	2035	2050
United States															
Nuclear	10 000	9 100	7 700	90	90	90	30	30	30	155	140	125	155	140	125
Coal	2 100	2 100	2 100	50	40	35	30	25	25	90	100	110	90	90	100
Gas CCGT	1 500	1 500	1 500	60	50	40	35	40	40	70	80	90	70	75	80
Geothermal*	15 000	9 000	6 600	75	75	80	50	25	20	330	195	135	330	195	135
Solar PV	1 180	800	650	20	23	23	10	10	10	55	35	30	65	50	55
Wind onshore	1 670	1 590	1 540	42	44	44	10	10	10	45	40	40	50	45	45
Wind offshore	5 620	3 920	3 140	41	46	49	45	30	25	175	110	85	180	115	90
Electricity generation costs										75	85	100			
European Union															
Nuclear	10 000	8 800	7 500	80	85	85	35	35	35	175	150	135	170	145	140
Coal	2 000	2 000	2 000	25	n.a.	n.a.	120	n.a.	n.a.	235	n.a.	n.a.	210	n.a.	n.a.
Gas CCGT	1 500	1 500	1 500	15	10	10	115	120	150	255	295	340	200	225	200
Geothermal*	21 630	18 130	16 730	75	75	80	55	45	45	455	380	330	450	370	320
Solar PV	780	530	440	13	13	13	10	10	10	55	40	35	65	70	70
Wind onshore	1 730	1 640	1 590	29	30	30	15	15	15	65	60	55	75	75	75
Wind offshore	3 760	2 740	2 180	50	54	55	20	15	10	85	55	45	85	65	60
Electricity generation costs										130	110	100			
China															
Nuclear	2 600	2 500	2 400	85	75	75	25	25	25	65	65	65	65	65	65
Coal	800	800	800	50	30	20	40	40	40	60	75	95	55	60	75
Gas CCGT	820	860	860	25	20	15	70	65	75	110	115	135	100	90	105
Geothermal*	16 050	11 050	9 050	75	75	80	55	30	25	320	215	165	320	215	165
Solar PV	530	350	280	12	12	12	10	10	10	45	30	25	65	55	60
Wind onshore	790	740	720	23	23	24	10	10	10	40	35	35	45	45	60
Wind offshore	1 540	1 120	900	30	32	32	15	10	10	65	45	35	70	55	60
Electricity generation costs										70	70	60			
India															
Nuclear	3 300	3 200	3 000	75	80	80	30	30	30	85	80	75	85	80	75
Coal	1 200	1 200	1 200	70	75	70	35	45	50	60	65	70	60	65	65
Gas CCGT	1 100	1 100	1 100	30	35	40	55	65	75	100	100	110	95	95	100
Geothermal*	19 500	15 000	13 200	75	75	80	75	55	45	400	305	250	400	305	250
Solar PV	540	350	280	20	20	21	5	5	5	35	20	15	40	30	45
Wind onshore	1 170	1 110	1 060	27	29	30	15	10	10	55	50	45	60	55	55
Wind offshore	2 860	2 100	1 620	34	38	39	25	20	15	120	80	60	120	85	70
Electricity generation costs										70	70	60			

*Next-generation geothermal.

Sources: IEA analysis; IRENA (2026).

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Table B.4c ▷ Technology costs in selected regions in the Net Zero Emissions by 2050 Scenario

	Capital costs (USD/kW)			Capacity factor (%)			Fuel, CO_2, O&M (USD/MWh)			LCOE (USD/MWh)		
	2025	2035	2050	2025	2035	2050	2025	2035	2050	2025	2035	2050
United States												
Nuclear	10 000	8 800	7 200	90	85	85	30	30	30	155	140	125
Coal	2 100	2 100	2 100	25	n.a.	n.a.	100	n.a.	n.a.	205	n.a.	n.a.
Gas CCGT	1 500	1 500	1 500	30	10	n.a.	60	95	n.a.	120	365	n.a.
Geothermal*	15 000	6 600	3 560	75	75	80	50	20	10	330	140	70
Solar PV	1 180	720	580	20	23	23	10	10	10	55	35	30
Wind onshore	1 670	1 550	1 500	42	44	44	10	10	10	45	40	40
Wind offshore	5 620	3 240	2 680	41	46	49	45	30	25	175	90	75
Electricity generation costs										75	100	90
European Union												
Nuclear	10 000	8 700	7 200	80	75	70	35	35	35	175	165	150
Coal	2 000	2 000	2 000	15	n.a.	n.a.	150	215	250	315	n.a.	n.a.
Gas CCGT	1 500	1 500	1 500	15	n.a.	n.a.	125	n.a.	n.a.	280	n.a.	n.a.
Geothermal*	21 630	16 030	14 000	75	75	80	55	40	35	455	335	280
Solar PV	780	500	400	13	13	13	10	10	10	55	40	35
Wind onshore	1 730	1 610	1 560	29	30	30	15	15	15	65	60	55
Wind offshore	3 760	2 300	1 900	50	54	55	20	10	10	85	50	40
Electricity generation costs										130	100	95
China												
Nuclear	2 600	2 500	2 300	90	90	90	25	25	25	60	60	55
Coal	800	800	800	40	n.a.	n.a.	80	n.a.	n.a.	105	n.a.	n.a.
Gas CCGT	820	860	860	30	20	20	85	100	120	120	150	175
Geothermal*	16 050	8 050	5 150	75	75	80	55	25	15	320	160	95
Solar PV	530	320	260	12	12	12	10	10	5	45	30	25
Wind onshore	790	720	700	23	23	24	10	10	10	40	35	30
Wind offshore	1 540	900	740	30	32	32	15	10	10	65	35	30
Electricity generation costs										70	75	50
India												
Nuclear	3 300	3 200	2 900	80	80	75	30	30	30	80	80	80
Coal	1 200	1 200	1 200	55	25	n.a.	30	135	n.a.	60	195	n.a.
Gas CCGT	1 100	1 100	1 100	25	25	n.a.	50	95	n.a.	100	150	n.a.
Geothermal*	19 500	12 300	9 690	75	75	80	75	45	35	400	250	185
Solar PV	540	330	250	20	20	21	5	5	5	35	20	15
Wind onshore	1 170	1 080	1 030	27	29	29	15	10	10	55	50	45
Wind offshore	2 860	1 700	1 380	34	38	39	25	15	10	120	65	55
Electricity generation costs										70	80	50

*Next-generation geothermal.

Sources: IEA analysis; IRENA (2026).

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B.5 Other key technology costs

Table B.5 ▷ Costs for selected technologies by scenario

		Current Policies Scenario		Stated Policies Scenario		Net Zero Emissions by 2050 Scenario	
	2025	2035	2050	2035	2050	2035	2050
Levelised cost of iron-based steel production (2025 USD/t)							
Conventional							
Lower range	520	530	520	520	510	550	690
Upper range	640	630	620	650	690	790	820
Innovative							
Lower range	n.a.	960	900	890	870	690	700
Upper range	n.a.	1010	940	1030	980	830	870
Vehicles (2025 USD/vehicle)							
Hybrid cars	17 900	16 200	16 100	16 100	16 000	15 900	15 800
Battery electric cars	20 300	16 600	15 800	16 100	15 100	15 500	14 600
Hydrogen (2025 USD/kW)							
Hydrogen electrolysers							
Lower range	550	440	390	420	390	330	310
Upper range	2 500	1 780	1 550	1 750	1 530	1 370	1 230
Fuel cells							
Trucks	360	250	230	240	200	150	80
Utility-scale stationary batteries (2025 USD/kWh)							
2-hour batteries	195	140	110	135	105	135	110
4-hour batteries	190	130	100	125	100	125	100
8-hour batteries	155	115	85	115	85	115	95

Notes: t = tonne; kW = kilowatt; kWh = kilowatt-hour; n.a. = not applicable.

Sources: IEA analysis; BNEF (2025); NREL (2021); Financial Times (2020); JATO (2021); S&P Global Mobility (2024); JRC (2018).

- All costs represent fully installed or delivered technologies, not solely the module cost, unless otherwise noted. Installed or delivered costs include engineering, procurement and construction costs to install the module.
- Iron-based steel production costs display a range considering technology and regional differences, e.g. capital expenditure, operating expenditure and learning rate, and differentiate between conventional and innovative production routes. Levelised cost of production includes estimated iron ore prices, carbon prices and fuel subsidies differentiated by region and scenario, and it is weighted by regional deployment. Conventional routes are blast furnace-basic oxygen furnace (BF-BOF) and direct reduced iron-electric arc furnace (DRI-EAF). The innovative routes are BF-BOF with carbon capture, utilisation and storage (CCUS), DRI-EAF with CCUS, and 100% electrolytic hydrogen-based DRI-EAF.

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- Vehicle costs reflect production costs, not retail prices, to better capture the declines in total cost of manufacturing. They represent a global average, evolving in line with the regions' roles in the global market and their respective production costs.
- Electrolyser costs reflect a weighted average among different electrolysis technologies. The lower value for hydrogen electrolysers refers to China and the upper one to the rest of the world.
- Fuel cell costs are based on stack manufacturing costs only, not installed or delivered costs. The costs provided are for automotive fuel cell stacks for trucks.
- Utility-scale stationary battery costs reflect the global average installed costs of all battery systems rated to provide maximum power output for two-, four- and eight-hour periods.

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B.6 CO_2 prices

Table B.6 ▷ CO_2 prices in selected regions by scenario

USD (2025, MER) per tonne of CO_2	2035	2040	2050
Current Policies Scenario*			
Advanced economies	12	12	12
Selected emerging market and developing economies**	1.9	1.9	1.9
Other emerging market and developing economies	< 1	< 1	< 1
Stated Policies Scenario*			
Advanced economies	26	30	47
Selected emerging market and developing economies**	3.8	4.6	6.2
Other emerging market and developing economies	< 1	1.4	2.3
Net Zero Emissions by 2050 Scenario			
Advanced economies	180	205	250
Selected emerging market and developing economies**	125	160	200
Other emerging market and developing economies	20-50	25-85	40-180

*CO_2 prices are weighted averages across all covered energy sectors and countries within the region.

**Includes Argentina, Brazil, China, India, Indonesia and South Africa.

Notes: MER = market exchange rate. Values are rounded.

- There are 87 direct carbon pricing instruments in place today, covering 58 countries and 42 sub-national jurisdictions. Global carbon pricing revenues in 2025 rose slightly, by 2% from 2024 levels, to around USD 107 billion (World Bank, 2026b).
- The CPS considers only implemented and enforced carbon pricing mechanisms in place as of August 2026. It does not consider planned carbon pricing policies or extensions or expansions of existing schemes that have a stated end date. Existing and scheduled CO_2 pricing schemes are reflected in the STEPS. In the NZE Scenario, CO_2 prices cover all regions and rise over time. Prices are generally higher in advanced economies and lower in emerging market and developing economies.

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B.7 Policies

- The policy actions taken by governments are key inputs in the *World Energy Outlook*. An overview of the policies, measures and targets considered in the various scenarios is included in Tables B.7 to B.11. The tables do not include all policies and measures but rather highlight the latest prominent policies shaping global and regional primary energy demand and supply today. A more complete policy dataset can be accessed through the publicly available IEA Global Energy Policies Hub (IEA, 2026).
- The policies are additive: measures listed under the STEPS are supplemental to the policies in the CPS. The tables detail policies by sector: electricity generation, industry, buildings, transport and energy supply.
- Table B.12 lists key industry- and intergovernmental-led initiatives considered fully met globally in the NZE Scenario.

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Table B.7 ▷ Selected electricity sector policies and measures as modelled by scenario for selected regions/countries

Region/ country	Scenario	Policies and targets
United States	CPS	• The One Big Beautiful Bill Act (2025), including an accelerated phase out schedule for tax credits for wind and solar, and stricter ownership and sourcing rules. • Reinvigorating the Nuclear Industrial Base Executive Order. • Repeal in progress for Environmental Protection Agency Clean Power Plan 2.0 and finalised for the Mercury and Air Toxics Standards Rule. • State-level renewable and clean energy mandates established through legislation or executive orders, including 20 states and the District of Columbia with 100% targets within the 2032 to 2050 period.
	STEPS	• State-level renewable and clean energy targets extended and strengthened beyond current expiration dates.
Canada	CPS	• A Healthy Environment and a Healthy Economy, including reaching nearly 90% non-emitting electricity generation by 2030. • Phase out conventional coal-fired plants by 2030 under the Canadian Environmental Protection Act.
	STEPS	• Nuclear Energy Strategy aims to deploy up to 10 new large reactors by 2040.
Latin America and the Caribbean	CPS	• Brazil: Ten-year Energy Expansion Plan 2035. • Chile: Phase out unabated coal use by 2040 under the Decarbonisation Plan. National Energy Policy target for 80% of total national electricity generation to come from renewable sources by 2030. • Colombia: 6 GW Plus Plan to accelerate solar and wind deployment and reduce project bottlenecks. • A total of 18 of 33 countries in the region have targets to expand renewables electricity in their national energy policies.
	STEPS	• Argentina: National Energy Transition Plan to 2030, including at least 50% electricity from renewable sources, of which 1 GW is distributed renewables capacity by 2030. • Mexico: Electricity Sector Development Plan 2025-2039. • An additional 10 of 33 countries in the region have targets to expand renewables electricity in their transition and expansion plans.
Japan	CPS	• Alternative generation mix aligned with the 7th Strategic Energy Plan. • Restart nuclear power plants aligned with the 7th Strategic Energy Plan and the Green Transformation policy initiative.
	STEPS	• Reference electricity generation mix in the 7th Strategic Energy Plan, targeting 40-50% renewable energy and 20% nuclear by 2040.
Korea	CPS	• The 11th Basic Plan for Long-term Electricity Supply and Demand, including 35% electricity generation from nuclear, and along with renewables, reaching over 70% electricity generation from low-emissions sources by 2038.
	STEPS	• Extension of higher targets for low-emissions electricity generation under the 11th Basic Plan for Long-term Electricity Supply and Demand beyond 2038. • Renewable Energy Plan targeting 100 GW of renewables by 2030 and at least 30% of electricity generation from renewables by 2035.
Australia and New Zealand	STEPS	• Australia: Progress towards reaching 82% renewables electricity generation target by 2030.

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Table B.7 ▷ Selected electricity sector policies and measures as modelled by scenario for selected regions/countries (continued)

Region/ country	Scenario	Policies and targets
European Union	CPS	• Coal phase out commitments as specified by 14 member states. Twelve EU member states are already coal free or have never used coal in electricity generation. • National Energy and Climate Plans (2023-2026) submitted by member states. • Updated development plans for nuclear in Belgium, the Czech Republic, Poland and the Slovak Republic.
	STEPS	• Coal phase out commitments fulfilled at the earliest time announced by member states.
Other Europe	STEPS	• Türkiye: Emissions trading system to start its full compliance period in 2028. • United Kingdom: Clean Power 2030 Action Plan sets targets to expand offshore wind, solar PV and nuclear power. Long-duration electricity storage investment support measure.
China	CPS	• The 15th Five-Year Plan targeting 3 500 GW of renewables by 2030. Non-fossil fuel generation to reach 50% by 2030. • China Energy Law (2025), including promoting renewable energy through minimum consumption targets for utilities, consumers and captive power plants, and setting renewable energy quotas for provinces. • Power market reform to reduce curtailment and promote spot markets, including Market-oriented Reform of New Energy Feed-in Tariffs in 2025.
	STEPS	• Extension of provincial and national non-fossil fuel generation targets beyond the current expiration dates. • Further expansion of power market reforms to additional provinces and enhancement of interprovincial exchanges (improving integration of renewables).
India	CPS	• National Electricity Plan (2024) including renewables purchase obligations, 47 GW of battery storage and 27 GW of pumped hydro, and expansion of regional grid interconnections by 2032. • Government commitment for 500 GW of non-fossil fuel capacity by 2030. • Carbon Credit Trading Scheme with a compliance period starting in 2026.
	STEPS	• Expanded R&D funding to develop small modular reactors under the 2025 India Nuclear Energy Mission. • Beyond 2030, extension and strengthening of targets for non-fossil fuel generation capacity.
South and Southeast Asia	CPS	• Indonesia: Electricity Supply Business Plan 2025-2034 aims to add 42 GW of renewables along with IDR 400 trillion (USD 25 billion) of investment in transmission networks. • Viet Nam: Progress towards reaching targets under Adjusted Power Development Plan 8 to install over 45 GW of solar PV and 20-38 GW of onshore wind by 2030 and phasing out coal-fired generation by 2050.
	STEPS	• ASEAN: 45% renewables capacity by 2030. • Cambodia: Power Development Plan 2022-2040 targets 3.2 GW of solar capacity and 3 GW of hydropower by 2040. • Thailand: Draft Power Development Plan 2026 aims at least 65% share of clean electricity by 2050 with a possibility of reaching 90%.

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Table B.7 ▷ Selected electricity sector policies and measures as modelled by scenario for selected regions/countries (continued)

Region/ country	Scenario	Policies and targets
Africa	CPS	• Egypt: El Dabaa nuclear plant reaching full capacity by 2030. • South Africa: Integrated Resource Plan 2025.
	STEPS	• Libya: National Strategy for Renewable Energy & Efficiency 2023-2035 aims to increase the share of renewables to 20% by 2035. • Morocco: Long-term strategy target of increasing the share of renewables to 52% of electrical capacity by 2030. • Tunisia: Target of increasing the share of renewables to 30% in its electricity mix by 2030. • Tanzania: Power System Master Plan 2025.
Middle East	CPS	• Jordan: Energy Strategy 2025-2035, including 40% renewables share in electricity generation by 2035. • Lebanon: Policy Statement, including at least 30% of generation capacity from renewable sources by 2030.
	STEPS	• Qatar: National Renewable Energy Strategy to increase the share of renewable energy to 18% in the electricity generation mix by 2030. • Saudi Arabia: Saudi Vision 2030 aims to phase out oil use in power and provide 50% of electricity generation from renewables by 2030.

Note: GW = gigawatt; MW = megawatt; CPS = Current Policies Scenario; STEPS = Stated Policies Scenario; ASEAN = Association of Southeast Asian Nations; EU = European Union; IDR = Indonesian rupiah; PV = photovoltaic; R&D = research and development.

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Table B.8 ▷ Selected industry sector policies and measures as modelled by scenario for selected regions/countries

Region/ country	Scenario	Policies and targets
United States	STEPS	• Declaration of National Emergency to Increase Competitive Edge, Protect Sovereignty, and Strengthen National and Economic Security (2025). • Energy Conservation Standards for selected Electric Motors types to International Efficiency (IE) 4 by 2027.
Canada	CPS	• Disbursement of clean industry packages and provisions to promote clean industry, as part of Building Canada's Clean Industrial Advantage, only for projects under construction.
	STEPS	• Full disbursement of clean industry provisions, extended beyond current budget allocations. • 2030 Emissions Reduction Plan including measures for heavy industry, such as support ISO 50001 certification and CCUS development. • Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.
Latin America and the Caribbean	CPS	• Brazil: Disbursement of the energy efficiency guarantee fund. • Colombia: Tax break on energy efficiency investment (2014).
	STEPS	• Brazil: Greenhouse Gas Emissions Trading System; 2024 Brazil Industry Decarbonization investment programme (Nova Indústria Brasil); Transformative Investment Programme for Energy Efficiency in Industry. • Argentina: Industry 4.0 development plan to promote efficiency and high-tech industries; Argentinian Productivity Plan 2030 to modernise and increase the productivity of traditional manufacturing sectors. • Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.
Japan	CPS	• Disbursement of the Green Innovation Fund (USD 13 billion R&D funding for transportation equipment and manufacturing-related industries until 2030), only for projects under construction. • Green Transformation Emissions Trading System (GX-ETS, 2026).
	STEPS	• Green Innovation Fund, extended support for transportation equipment and manufacturing-related industries beyond 2030. • Phase-down of free allowances under the GX-ETS by 2033; GX-Surcharge starting in 2028. • Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.
Korea	CPS	• Disbursement of the Green Infrastructure Overseas Export Support Fund, including its second round of funding in 2025, only for projects under construction.
	STEPS	• Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.
Australia and New Zealand	CPS	• Australia: Disbursement of the Industrial Transformation Stream (USD 260 million) and National Industrial Transformation Programme (USD 26 million), only for projects under construction. • Australia: Safeguard Mechanism for large greenhouse gas emitters.
	STEPS	• Australia: Full disbursement of the Industrial Transformation Stream, National Industrial Transformation Programme and Net Zero Fund. • New Zealand: Ban on new low- and medium-temperature coal boilers in industries as well as phase-out of existing ones by 2037. • Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.

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Table B.8 ▷ Selected industry sector policies and measures as modelled by scenario for selected regions/countries (continued)

Region/ country	Scenario	Policies and targets
European Union	CPS	• Disbursement of the EU Innovation Fund support for renewables, energy-intensive industries, storage and CCUS, only for projects under construction. • European Union Emissions Trading System (EU ETS), including partial implementation of free allowances phase-out. • France: Disbursement of the Green Industry Bill funding to create new green industries and accelerate the decarbonisation of existing ones, only for projects under construction. • Germany: Disbursement of the Federal Fund for Industry and Climate Action, only for projects under construction.
	STEPS	• EU Clean Industrial Deal. • EU ETS including phasing out of some industry free allowances with the implementation of the Carbon Border Adjustment Mechanism from 2026. • Energy efficiency and decarbonisation provisions, extended support for renewables, energy-intensive industries, storage and CCUS beyond currently announced funds through the Industrial Decarbonisation Bank. • Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.
Other Europe	CPS	• United Kingdom: Disbursement of the Industrial Energy Transformation Fund (with total grant funding of up to USD 640 million until 2028), only for projects under construction.
	STEPS	• United Kingdom: Modern Industrial Strategy. Energy efficiency and decarbonisation provisions, extended support for low-emissions industrial clusters beyond 2028. Emissions trading system, including phasing out of some industry free allowances with the implementation of the Carbon Border Adjustment Mechanism from 2027. • Israel: Assistance Track For Investments In Projects For Conversion (2026). • Ukraine: Affordable loans at 5-7-9% to companies. • Türkiye: 2030 Industry and Technology Strategy. Emissions trading system to start its full compliance period in 2028. • Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.
Eurasia	CPS	• Russia: Mandatory carbon reporting for companies emitting 150 000 tonnes of CO_2-eq or more per year, and between 50 000 and 150 000 tonnes of CO_2-eq starting in 2023 and 2025, respectively.
	STEPS	• Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.

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Table B.8 ▷ Selected industry sector policies and measures as modelled by scenario for selected regions/countries (continued)

Region/ country	Scenario	Policies and targets
China	CPS	• China Green Electricity Certificate, with a mandatory proportion of green power consumption for data centres, iron and steel, non-ferrous metals, building materials, petrochemicals and chemical industries (2025). • China emissions trading system expansion to cement, steel and aluminium (2025).
	STEPS	• 15th Five-Year Plan: Expansion of scrap-based EAF steel production. • Implementation Plan for Accelerating the Application of Clean and Low-Carbon Hydrogen in the Industrial Sector by 2027. • Action Plan for Large-Scale Equipment Upgrades and Consumer Goods Trade-in. • Key Research Directions for Green and Low-Carbon Standards in Industry and Information Technology 2025-2027. • Industrial Capacity Replacement Policy: upward revision of the steel capacity replacement ratio to 1.5:1, and to 2:1 for clinker capacity. Provincial and technology exceptions apply. • Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.
India	CPS	• Disbursement of the Make in India programme, only for projects under construction. • Disbursement of the Production Linked Incentives programme (subsidies related to new manufacturing capacity for solar PV and modern batteries), only for projects under construction. • Mandatory energy audits under the Energy Conservation Act. • India Carbon Credit Trading Scheme (2026).
	STEPS	• Manufacturing provisions, extended support for advanced manufacturing programmes beyond 2029. • National Mission for Enhanced Energy Efficiency. • National Steel Policy. • Steel Scrap Recycling Policy. • Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.
South and Southeast Asia	CPS	• Indonesia: Emissions trading system (2023). Green Industry Standards and the Regulation on Energy Conservation. • Pakistan: National Energy Efficiency and Conservation Act (2016).
	STEPS	• Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.
Africa	CPS	• Nigeria: Value-added tax exemption for energy-related goods and services, including steel and bars for LNG processing (2025).
	STEPS	• Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.
Middle East	STEPS	• Beyond current expiration dates, extension and strengthening of existing efficiency and decarbonisation regulations in accordance with the latest available standards.

Note: EU = European Union; R&D = research and development; CCUS = carbon capture, utilisation and storage; EAF = electric arc furnace; GX = Green Transformation; LNG = liquefied natural gas; PV = photovoltaic.

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Table B.9 ▷ Selected buildings sector policies and measures as modelled by scenario for selected regions/countries

Region/ country	Scenario	Policies and targets
United States	CPS	• State-level building energy codes for new buildings, including 12 states with revised and updated energy codes (2021 or 2024 International Energy Conservation Code).
	STEPS	• Extension of existing state-level support for efficient space and water heating equipment, and building envelope improvements.
Canada	CPS	• Updated National Energy Code of Canada for Buildings (2025). • MEPS for equipment and appliances, including 2025 amendments for air conditioners, heat pumps and boilers.
	STEPS	• Greener Homes Affordability Programme and Oil to Heat Pump Affordability Programme. • Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.
Latin America and the Caribbean	CPS	• Brazil: Revised building energy codes for new construction (2025); Updated MEPS for air conditioners (2022). • Chile: Revision of MEPS for indoor lighting, effectively banning the sale of less efficient technologies (2025). • Colombia: Mandatory building energy codes applied to new construction covered under Resolution 0549 (2015). • Peru: Updated building energy codes for new buildings (2021). • Common regulation on MEPS (2022) for air conditioners in Costa Rica, El Salvador, Guatemala, Honduras, Nicaragua and Panama.
	STEPS	• Chile: Better Homes subsidy scheme to improve thermal conditioning and energy efficiency (2025). • Colombia: Subsidies for household purchases of efficient lighting, refrigeration and cooking equipment, established in partnership with the Inter-American Development Bank (2023). • Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.
Japan	CPS	• Strengthened MEPS for air conditioners, water heaters, glazing and televisions, introduced as part of the changes to the Top Runner Programme for 2025-2027. • Revised mandatory building energy codes applied to all new construction covered under the Act on the Improvement of Energy Consumption Performance of Buildings (2022).
	STEPS	• Subsidies for retrofits and efficient water heaters, introduced as part of the Residential Energy Conservation Campaign (2024). • Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.
Korea	CPS	• Revised MEPS for washing machines, air conditioners and dryers (2026). • Updated building energy codes for new construction (2023).
	STEPS	• Korea Electric Power Corporation (KEPCO) Programme: Subsidies for highly energy-efficient appliances, distributed via on-bill rebates. • Korean New Deal: Increased funding to improve the efficiency of schools, public housing, and recreational and healthcare facilities. • Subsidised interest payments for retrofit projects, provided under the Green Remodelling Interest Support Programme. • Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.

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Table B.9 ▷ Selected buildings sector policies and measures as modelled by scenario for selected regions/countries (continued)

Region/ country	Scenario	Policies and targets
Australia and New Zealand	CPS	• Australia: Updated energy efficiency standards for new homes (2022). Updated MEPS for air conditioners and heat pumps (2022). • New Zealand: Replacement of all coal-fired boilers in schools with electric or renewable biomass alternatives by 2025; update of the building energy code (2025).
	STEPS	• Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.
European Union	CPS	• Nearly Zero-Energy Building requirements applied to all new construction as of 2021. • Requirement to renovate 3% of the floor area of public buildings annually, mandated under the Energy Efficiency Directive (2018). • National and sub-national bans and policies to limit the installation of certain fossil fuel boilers in buildings.
	STEPS	• EU funding instruments that support national building renovation programmes, including the European Regional Development Fund, Cohesion Fund, Social Climate Fund, InvestEU, European Local Energy Assistance (ELENA), and Programme for the Environment and Climate Action (LIFE). • Carbon pricing for buildings, introduced from 2028 onwards via the EU Emissions Trading System 2. • Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.
Other Europe	CPS	• Türkiye: Updated building energy codes for all new buildings and large existing buildings, and all new public buildings to be nearly zero-energy buildings (2023). • United Kingdom: Updated building energy codes for new buildings (2026).
	STEPS	• United Kingdom: Low-Carbon Heat Scheme and Green Heat Network Fund; Warm Homes Plan; Clean Heat Market Mechanism. Financial incentives to purchase clean household technologies. Extended support for efficient appliances and retrofits. • Ukraine: Voluntary certification for nearly zero-energy buildings (2025). • Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.
Eurasia	CPS	• Russia: Revised building energy codes for new construction (2018). • Kyrgyzstan: Requirements for public bodies to purchase highly efficient energy-consuming appliances and equipment (2025). • Uzbekistan: Tax exemptions for producers of renewable energy equipment and customers of off-grid renewable installations in residential buildings (2019).
	STEPS	• Georgia: Law on Energy Efficiency for Buildings to require all new construction after 30 September 2029 to meet the requirements for Nearly Zero-Energy Building. • Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.
China	CPS	• Green building incentives and subsidies in various provinces. • Updated MEPS for air conditioners and heat pumps (2024). • General Code for Building Energy Efficiency and Renewable Energy Utilisation (2022).
	STEPS	• National financing allocated for replacement of appliances with more efficient alternatives in line with the Action Plan for Promoting the Replacement of Consumer Goods (2024). • Action Plan for Large-Scale Equipment Upgrades and Consumer Goods Trade-in (2025). • Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.

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Table B.9 ▷ Selected buildings sector policies and measures as modelled by scenario for selected regions/countries (continued)

Region/ country	Scenario	Policies and targets
India	CPS	• Revised building energy codes applied to new commercial buildings and large residential buildings in states where the federal framework has been adopted (2024). • Revised MEPS for room air conditioners (2025). • Partial disbursement of the subsidy scheme for residential rooftop PV systems (2024).
	STEPS	• Bachat Lamp Yojana Lighting Programme (2009) and full disbursement of the subsidy scheme for residential rooftop PV systems (2024). • Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.
South and Southeast Asia	CPS	• Singapore: Revised mandatory building energy codes applied to new large construction (2025). • Indonesia: Updated MEPS for air conditioners (2021). • Viet Nam: Mandatory building energy codes applied to new large construction (2022).
	STEPS	• Singapore: Extension of subsidies for retrofits provided as part of the GMIS Programme (2022). • Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.
Africa	CPS	• South Africa: Mandatory building energy code for new construction (2021). • Nigeria: National building energy code for new construction (2017). • Kenya: Revised building energy code for new construction (2022). • MEPS for lighting (South Africa, 2022); air conditioners (Nigeria, 2025); air conditioners, refrigerators, water heaters and lighting (Ghana, 2022). • East African Community: MEPS for air conditioners and refrigerators (2025). • 82 new or updated access programmes for clean cooking implemented since 2025.
	STEPS	• Mozambique: Replacement of 2.5 million incandescent lamps with efficient lamps for all domestic consumers in the country. • Strengthening of existing efficiency regulations for appliances and buildings, extension of incentive programmes and continuation of energy access programmes and policies beyond current expiration dates.
Middle East	CPS	• Qatar: The Energy & Water Conservation Code sets minimum efficiencies for HVAC (2023). • Saudi Arabia: Green Energy Code (2025); updated MEPS for air conditioners (2021). • United Arab Emirates: MEPS for air conditioners (2019); emirate-level building energy codes for new construction.
	STEPS	• Saudi Arabia: Extension of energy efficiency project grants provided under the Public Investment Fund Green Finance Framework. • United Arab Emirates: Efficient Appliances Procurement Policy (2026); extension of the smart meter rollout programme in Dubai. • Strengthening of existing efficiency regulations for appliances and buildings, and extension of incentive programmes beyond current expiration dates.

Note: MEPS = minimum energy performance standards; HVAC = heating, ventilation and air conditioning.

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Table B.10 ▷ Selected transport sector policies and measures as modelled by scenario for selected regions/countries

Region/ country	Scenario	Policies and targets
United States	CPS	• One Big Beautiful Bill Act (2025): Includes the phase-out of EV tax credits available through September 2025 and eliminates penalties for automakers that fail to meet fuel-economy standards for passenger cars and light trucks. • Renewable Fuel Standard for biofuel volumes across all transport modes to 2027.
	STEPS	• Proposed Safer Affordable Fuel-Efficient (SAFE) Vehicles Rule III: Would require the fuel economy of new cars and light trucks to improve by 0.5% per year from MY2022 through MY2026, followed by a 0.25% improvement per year through MY2031, with MY2027 as a bridge between the two.
Canada	CPS	• Electric Vehicle Availability Standard sets annual zero-emissions light-duty vehicle sales targets to 2035, though the mandate for 2026 was waived. • CO_2 emission standards for heavy-duty vehicles to reduce emissions by 5% to 27% in 2027, compared to 2017. • British Columbia: Low Carbon Fuels Act mandates a renewable jet fuel share of 1% in 2028, 2% in 2029 and 3% in 2030.
	STEPS	• Fuel economy improvements of heavy-duty vehicles beyond 2027. • Proposed repeal of the Electric Vehicle Availability Standard and replacement with greenhouse gas emission standards to achieve 75% electric light-duty vehicle sales by 2035 and 90% by 2040. • Electric Vehicle Affordability Programme (2026-2031).
Latin America and the Caribbean	CPS	• Argentina: Existing blending mandates for ethanol in gasoline of 12% and biodiesel in diesel of 5%. • Mexico: Revised CO_2 emission standards with stricter emissions limits on new light-duty vehicles up to MY2027. • Chile: Partial implementation of fuel-economy standards for light-duty vehicles to reduce the level to around 3.5 litres/100 km by 2030. • Brazil: Reduction of at least 1% of CO_2 emissions in domestic aviation with use of sustainable aviation fuel from 2027, increasing to 10% by 2037. Partial implementation of a 20% biodiesel blending mandate across all transport modes by 2030.
	STEPS	• Mexico: Fuel economy improvements of light-duty vehicles beyond 2027. • Chile: Fuel economy improvements of light-duty vehicles beyond 2030. • Brazil: Temporary increase in the mandatory ethanol blend in gasoline from 30% to 32% until the end of June 2027.
Japan	CPS	• Fuel-economy standard for light-duty vehicles to improve fuel efficiency by 32% to 2030 relative to 2016 levels.
	STEPS	• Subsidies for the purchase of clean energy vehicles toward the realisation of the Green Transformation (GX) policy in the automobile sector. • Fuel economy improvements in light-duty vehicles beyond 2030.

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Table B.10 ▷ Selected transport sector policies and measures as modelled by scenario for selected regions/countries (continued)

Region/ country	Scenario	Policies and targets
Korea	CPS	• 2021 GHG standard reaching 70 g CO_2/km and fuel-economy standard of 33.1 km/litre by 2030 for new passenger cars. • ZEV sales share target for new cars of 50% by 2030. • Biodiesel blending mandate of 5% by 2030.
	STEPS	• Additional subsidies for the purchase of private and commercial light-duty EVs, hydrogen buses, medium- and heavy-freight EVs, and for conventional vehicle scrappage. Budget for EV charging infrastructure, and a public-private investment fund to support EVs. • Fuel economy improvements in passenger cars to continue beyond 2030. • Target of 60% for new two-wheeled vehicles for delivery to be electric.
Australia and New Zealand	CPS	• Australia: New Vehicle Efficiency Standard Act to reduce emissions of new passenger and light commercial vehicles by 2029 to 58 g CO_2/km and 110 g CO_2/km, respectively, measured using the New European Driving Cycle. The CO_2 targets are adjusted as a function of vehicle weight. • New Zealand: Clean Vehicle Standard to reduce emissions of new passenger and light commercial vehicles by 2029 to 65 g CO_2/km and 131 g CO_2/km, respectively. The CO_2 targets are adjusted as a function of vehicle weight.
	STEPS	• Fuel economy improvements in light-duty vehicles beyond 2029. • Australia: Future Fuels Fund. • New Zealand: Low Emissions Heavy Vehicle Fund.
European Union	CPS	• CO_2 emission standards for both new cars and vans for 2030 and 2035, including an amendment in 2025 for the 2025-2027 period. • CO_2 emission standards for new heavy-duty vehicles with reduction targets up to 2040, including an amendment for 2030. • ReFuelEU Aviation initiative sets minimum shares of sustainable aviation fuels, starting from 2% in 2025 and reaching 70% by 2050, with sub-obligations for synthetic fuels. • FuelEU Maritime regulation targets the reduction of average GHG intensity of energy used on board ships up to 80% by 2050 relative to 2020 levels. • Alternative Fuels Infrastructure Regulation to accelerate the rollout of recharging infrastructure for EVs and hydrogen refuelling stations. Developing electricity infrastructure for maritime ports and airports. • Inclusion of the maritime sector in the EU Emissions Trading System (EU ETS) since January 2024.
	STEPS	• EU ETS II for transport fuels to become operational in 2028. • Automotive Package reviewed CO_2 emission standards for cars and vans, mandating a 90% tailpipe emissions reduction target by 2035 and adding flexibility for 2030 targets. The remaining 10% will need to be compensated through EU-made low-carbon steel or e-fuels and biofuels.
Other Europe	CPS	• United Kingdom: ZEV mandate for new cars and vans by 2035, including compliance flexibilities that are in effect to 2029. CO_2 emissions reduction regulation for heavy-duty vehicles reducing CO_2 emissions by 30% in 2030 relative to 2019. SAF mandate to reach 10% SAF share in jet fuel demand by 2030 and 28% in 2040. • Switzerland: CO_2 emissions reduction regulation for light-duty vehicles.
	STEPS	• United Kingdom: Fuel economy improvements of heavy-duty vehicles beyond 2030. • Türkiye: High Technology Investment Programme with provisions for a USD 4.5 billion incentive for battery production and a USD 5 billion incentive to increase EV production.

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Table B.10 ▷ Selected transport sector policies and measures as modelled by scenario for selected regions/countries (continued)

Region/ country	Scenario	Policies and targets
Eurasia	CPS	• Georgia: VAT exemptions and reduced import taxes for EVs.
	STEPS	• Russia: Production support scheme for Russian automakers and battery producers to establish manufacturing plants.
China	CPS	• Half-rate tax exemption for new energy vehicles to 2027. • Trade-in subsidy scheme, renewed for 2026, for replacing fossil fuel-powered vehicles with new energy or fuel-efficient vehicles. • Subsidy for new energy city buses and battery replacement. • Corporate average fuel consumption target for light-duty vehicles of 4.0 litres/100 km in 2025 and 3.2 litres/100 km in 2030. Stage 4 fuel consumption standards for light commercial and heavy-duty commercial vehicles. • Three-year action plan to double charging capacity, including over 100 000 high-power chargers. • National railway energy intensity target of 10% reduction by 2030 compared to 2020.
	STEPS	• Energy efficiency improvement of national railway beyond 2030.
India	CPS	• Partial implementation of 5% biodiesel target by 2030.
	STEPS	• PM Electric Drive Revolution in Innovative Vehicle Enhancement and PM e-Bus Sewa-Payment Security Mechanism schemes to incentivise the uptake of electric two/three-wheelers, buses and freight vehicles. • The Corporate Average Fuel Economy III standard for passenger cars from 2027 to 2032.
South and Southeast Asia	CPS	• Indonesia: Reduced annual vehicle tax, 15% luxury tax rebate for BEVs meeting local content requirements, and expiration of 10% VAT discount and import duty exemptions after 2025. Biodiesel blending mandate (50%) and partial implementation of ethanol blending mandate (20%). • Malaysia: Preferential EV road tax treatment, reintroduction of import duties and minimum-price requirements for imported EVs from 2026. Grants related to the installation, rental or subscription of EV charging facilities at home. • Thailand: CO_2-based excise tax system, EV3.5 purchase subsidies and tax incentives for electric cars and 2/3Ws, expiration of import duty reliefs after 2025. • Philippines: EV excise tax exemption, EV import tariff exemption through 2028. • Viet Nam: BEV excise tax rebates, BEV registration fee exemptions. • Singapore: Vehicular Emissions Scheme, EV Early Adoption Incentive, Commercial Vehicle Emissions Scheme, Heavy Vehicle Zero Emissions Scheme.
	STEPS	• Indonesia: Reintroduction of purchase subsidies for electric 2/3Ws. • Viet Nam: Proposed extension of BEV excise tax rebates to 2030, proposed extension of registration fee exemptions to 2030, Hanoi gasoline motorcycle restrictions from 2026, Ho Chi Minh City gasoline motorcycle restrictions from 2027. • Singapore: Continuation of vehicle-emissions-based registration incentives and scrappage programmes already signalled by government policy.

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Table B.10 ▷ Selected transport sector policies and measures as modelled by scenario for selected regions/countries (continued)

Region/ country	Scenario	Policies and targets
Africa	CPS	• Morocco: Euro 6 standard for passenger cars. Customs duties and VAT exemption for EVs. Removal of the circulation tax for hybrid and electric vehicles. • Tunisia: Exemption from customs duties, reduced VAT rates and purchase subsidy for EVs. • Egypt: Custom duty exemption for battery electric vehicles.
	STEPS	• South Africa: Automotive Production and Development Programme to produce electric and hydrogen-powered vehicles. • Ethiopia: Target for 440 000 EVs by 2030.
Middle East	CPS	• Saudi Arabia: 2024-2028 Saudi Arabia Corporate Average Fuel Economy standards.
	STEPS	• Saudi Arabia: Fuel economy improvements beyond 2028.

Notes: km = kilometre; g CO_2/km = gramme of carbon dioxide per kilometre. EVs = electric vehicles; BEVs = battery electric vehicles; GHG = greenhouse gases; MY = model year; SAF = sustainable aviation fuel; VAT = value-added tax; ZEV = zero-emissions vehicle; 2/3Ws = two/three-wheelers. Light-duty vehicles include passenger cars and light commercial vehicles (gross weight <3.5 tonnes). Heavy-duty vehicles include medium-freight trucks (gross weight 3.5 to 15 tonnes), heavy-freight trucks (gross weight >15 tonnes) and buses.

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Table B.11 ▷ Selected energy supply policies and measures as modelled by scenario for selected regions/countries

Region/ country	Scenario	Policies and targets
United States	CPS	• Compliance deadlines for regulatory requirements relating to methane emissions from the oil and gas sector extended until 2027 (2025). • Clean Hydrogen Production Tax Credit to January 2028 (2025). Clean Fuel Production Credit extended through December 2029; Biodiesel Credit to December 2026 (2025).
Canada	CPS	• Regulation Respecting Reduction in the Release of Methane and Certain Volatile Organic Compounds (2018). • Clean Hydrogen Investment Tax Credit to 2034 (2023).
	STEPS	• Enhanced Methane Regulations and Landfill Methane Regulations (2025). • Hydrogen Strategy for Canada (2020).
Latin America and the Caribbean	CPS	• Brazil: Regulations to reduce flaring and extraordinary methane emissions (2020). RenovaBio performance-based carbon credits (2017) and REIDI scheme to foster biofuel production (2007). • Colombia: Requirements to undertake leak detection and repair, control flaring and reduce methane emissions (2017).
	STEPS	• Brazil: Industry Decarbonization investment programme (Nova Indústria Brasil), including 44 renewable hydrogen projects (2024). • Chile: National hydrogen target of 8-15 GW of electrolysis capacity by 2035, earmarking USD 2.8 billion in tax incentives for renewable hydrogen projects (2025).
Japan	CPS	• 15-year Contracts for Difference subsidy scheme for low-emissions hydrogen and ammonia imports (2024).
	STEPS	• Green Transformation basic policy (2023); Act on Carbon Dioxide Storage Business (2024).
Korea	CPS	• Clean Hydrogen Portfolio Standard (2024).
Australia and New Zealand	STEPS	• Australia: Hydrogen Production Tax Incentive starting in 2027 (2024).
European Union	CPS	• Regulation on methane emissions reduction in the energy sector, with less stringent import requirements (2024). • European Hydrogen Bank auctions (2022).
	STEPS	• Regulation on methane emissions reduction in the energy sector, with more stringent import requirements (2024). • EU Hydrogen Strategy (2020) and REPowerEU to produce 10 million tonnes of hydrogen by 2030 (2022). • Ban on imports of Russian LNG into the European Union from January 2027 for long-term contracts (2026).
Other Europe	CPS	• Norway: Amended regulations relating to measurement of petroleum for fiscal purposes and for calculation of CO_2-tax (2012). • United Kingdom: Guidance for Flaring and Venting during Production (2016).
	STEPS	• United Kingdom: Methane Action Plan (2025).
Eurasia	CPS	• Kazakhstan: Tax code on combustion of natural gas flaring (2017). • Uzbekistan: Tax on methane emissions and other environmental pollutants (2021).
China	CPS	• Emissions standard for coal mine methane (2008). • City clusters demonstration programme worth CNY 8 billion (USD 1.1 billion) (2026).
India	CPS	• Coal Mines Regulations (2017).

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Table B.11 ▷ Selected energy supply policies and measures as modelled by scenario for selected regions/countries (continued)

Region/ country	Scenario	Policies and targets
South and Southeast Asia	CPS	• Indonesia: Regulation on the Implementation of Flare Management in Oil and Gas Activities (2021).
Africa	CPS	• Nigeria: Gas Flaring, Venting and Methane Emissions (Prevention of Waste and Pollution) Regulations (2023). Tax incentives for reinjecting natural gas that would otherwise be flared (2025). • Ghana: Guidelines for managing methane emissions (2025).
Middle East	CPS	• United Arab Emirates: Conservation of Petroleum Resources Law, including flaring or venting methane restrictions (1978).
	STEPS	• United Arab Emirates: Updated National Hydrogen Strategy (2023).

Note: REIDI = Regime Especial de Incentivos para o Desenvolvimento da Infraestrutura.

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Table B.12 ▷ Selected industry- and intergovernmental-led initiatives and manufacturing targets met in the NZE Scenario

Initiatives	Pledge type	Signatories pledge
Buildings		
Buildings Breakthrough	Emissions reduction	Make near-zero emissions and resilient buildings the norm for new buildings by 2030.
Steel		
First Movers Coalition	Procurement	10% of near-zero emissions steel by 2030.
Net Zero Steel Initiative	Technology deployment	Bring near-zero emissions primary steel production technologies to market by 2030.
Glasgow Breakthrough	Procurement	Near-zero emissions steel to be preferred for every member of the coalition.
Cement		
Concrete Action for Climate	Emissions reduction	Achieve net zero carbon emissions from operations by 2050.
Rail		
UIC Railway Climate Responsibility Pledge	Emissions reduction	Align CO_2 emissions reduction to achieve carbon neutrality by 2050.
Aviation		
ICAO long-term aspirational goal	Emissions reduction	Net zero emissions from international aviation by 2050.
ICAO carbon-neutral growth goal	Emissions reduction	Offset CO_2 emissions of international aviation above 85% of 2019 levels.
Zero emissions vehicles		
Global MoU on Zero Emissions MHDVs	Technology deployment	100% of new MHDVs to be zero emissions by 2040.

Note: NZE = Net Zero Emissions by 2050 Scenario; UIC = International Union of Railways; ICAO = International Civil Aviation Organization; MoU = memorandum of understanding; MHDVs = medium- and heavy-duty vehicles.

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Definitions

This annex provides general information on terminology used throughout this report, including units and general conversion factors; definitions of fuels, processes and sectors; regional and country groupings; and abbreviations and acronyms.

Units

Area	km^2	square kilometre
	Mha	million hectares
Distance	km	kilometre
Emissions	ppm	parts per million (by volume)
	t CO_2	tonnes of carbon dioxide
	Gt CO_2-eq	gigatonnes of carbon-dioxide equivalent (using 100-year global warming potentials for different greenhouse gases)
	kg CO_2-eq	kilogrammes of carbon-dioxide equivalent
	g CO_2/km	grammes of carbon dioxide per kilometre
	g CO_2/kWh	grammes of carbon dioxide per kilowatt-hour
	kg CO_2/kWh	kilogrammes of carbon dioxide per kilowatt-hour
	USD/t CO_2	US dollars per tonne of carbon dioxide
Energy	MJ	megajoule (1 joule x 10^6)
	GJ	gigajoule (1 joule x 10^9)
	TJ	terajoule (1 joule x 10^{12})
	PJ	petajoule (1 joule x 10^{15})
	EJ	exajoule (1 joule x 10^{18})
	W	watt (1 joule per second)
	kW	kilowatt (1 watt x 10^3)
	MW	megawatt (1 watt x 10^6)
	GW	gigawatt (1 watt x 10^9)
	TW	terawatt (1 watt x 10^{12})
	kWh	kilowatt-hour
	MWh	megawatt-hour
	GWh	gigawatt-hour
	TWh	terawatt-hour
	MBtu	million British thermal units
Energy density	Wh/kg	watt-hours per kilogramme
Energy equivalence	boe	barrel of oil equivalent
	mboe/d	million barrels of oil equivalent per day
	toe	tonne of oil equivalent
	ktoe	thousand tonnes of oil equivalent
	Mtoe	million tonnes of oil equivalent
	Lge	litre of gasoline equivalent
	bcme	billion cubic metres of natural gas equivalent
	Mtce	million tonnes of coal equivalent (equals 0.7 Mtoe)
	btce	billion tonnes of coal equivalent

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Mass	kg	kilogramme
	t	tonne (1 tonne = 1 000 kg)
	kt	kilotonne (1 tonne x 10^3)
	Mt	million tonnes (1 tonne x 10^6)
	Gt	gigatonne (1 tonne x 10^9)
Monetary	USD million	1 US dollar x 10^6
	USD billion	1 US dollar x 10^9
	USD trillion	1 US dollar x 10^{12}
Volumetric	bcm	billion cubic metres
	tcm	trillion cubic metres
	barrel	one barrel of crude oil
	kb/d	thousand barrels per day
	mb/d	million barrels per day

General conversion factors for energy

		Multiplier to convert to:					
		EJ	Gcal	Mtoe	MBtu	bcme	GWh
Convert from:	EJ	1	2.388×10^8	23.88	9.478×10^8	27.78	2.778×10^5
	Gcal	4.1868×10^{-9}	1	10^{-7}	3.968	1.163×10^{-7}	1.163×10^{-3}
	Mtoe	4.1868×10^{-2}	10^7	1	3.968×10^7	1.163	11 630
	MBtu	1.0551×10^{-9}	0.252	2.52×10^{-8}	1	2.932×10^{-8}	2.931×10^{-4}
	bcme	0.036	8.60×10^6	0.86	3.41×10^7	1	9 999
	GWh	3.6×10^{-6}	860	8.6×10^{-5}	3 412	1×10^{-4}	1

Note: There is no generally accepted definition of barrel of oil equivalent (boe); typically, the conversion factors used vary from 7.15 to 7.40 boe per tonne of oil equivalent. Conversions to and from billion cubic metres of natural gas equivalent (bcme) are given as representative multipliers but may differ from the average values obtained by converting natural gas volumes between International Energy Agency (IEA) balances due to the use of country-specific energy densities. Lower heating values (LHV) are used throughout.

Currency conversions

Exchange rates *(2025 annual average)*	**1 US dollar (USD) equals:**
British Pound	0.76
Chinese Yuan Renminbi	7.19
Euro	0.88
Indian Rupee	87.16
Japanese Yen	149.66

Source: World Bank Data: Official exchange rate (Local Currency Units per USD, period average), https://data.worldbank.org/indicator/PA.NUS.FCRF, accessed November 2026.

Definitions

Agriculture: Includes all energy used on farms, in forestry and for fishing.

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Agriculture, forestry and other land use (AFOLU)**:** A sector included in greenhouse gas accounting frameworks which encompasses managed ecosystems. AFOLU emissions include greenhouse gas emissions from agriculture, land use, land-use change and forestry.

Ammonia (NH_3)**:** A compound of nitrogen and hydrogen (NH_3) that is an industrially produced input to fertiliser manufacturing, resulting in substantial carbon dioxide (CO_2) emissions from the use of fossil fuel inputs to generate the input hydrogen. With properties similar to liquefied petroleum gas, ammonia can also be used directly as a fuel in direct combustion processes, as well as in fuel cells, and can be cracked to release its hydrogen content. As it can be made from low-emissions hydrogen, ammonia has the potential to be a low-emissions fuel if the production process, including nitrogen separation, is powered by low-emissions energy. Produced in such a way, ammonia is considered a low-emissions hydrogen-based liquid fuel.

Aviation: This transport mode includes both domestic and international flights and their use of aviation fuels. Domestic aviation covers flights that depart and land in the same country; flights for military purposes are included. International aviation includes flights that land in a country other than the departure location.

Back-up generation capacity: Households and businesses connected to a main power grid may also have a source of back-up power generation capacity that, in the event of disruption, can provide electricity. Back-up generators are typically fuelled with diesel or gasoline. Capacity can be as little as a few hundred watts. Such capacity is distinct from mini-grid and off-grid systems that are not connected to a main power grid.

Battery storage: Energy storage technology that uses reversible chemical reactions to absorb, store and release electricity on demand.

Biodiesel: Diesel-equivalent fuel made from the transesterification of vegetable oils and animal fats, hydrogenated vegetable oil (HVO), and other processes such as gasification and fermentation.

Bioenergy: Energy content in solid, liquid and gaseous products derived from biomass feedstocks and biogas. It includes solid bioenergy, liquid biofuels and biogases. Excludes hydrogen produced from bioenergy, including via electricity from a biomass-fired plant, as well as synthetic fuels made with CO_2 feedstock from a biomass source**.**

Biogas: A mixture of methane, CO_2 and small quantities of other gases produced by anaerobic digestion of organic matter in an oxygen-free environment. It includes landfill gas and sewage sludge gas, and it can be upgraded by removing non-methane constituents, principally CO_2.

Biogases: Include both biogas and biomethane.

Biogasoline: Includes all liquid biofuels used as a substitute for gasoline.

Biojet kerosene: Kerosene substitute produced from biomass. It includes conversion routes such as hydro-processed esters and fatty acids (HEFA) and biomass gasification with Fischer-Tropsch synthesis. It excludes synthetic kerosene produced from biogenic carbon dioxide.

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Biomethane: Biomethane is near-pure methane produced either by "upgrading" biogas (a process that removes any carbon dioxide and other contaminants present in the biogas) or through the gasification of solid biomass followed by methanation. It is also known as renewable natural gas.

Buildings: The buildings sector includes energy used in residential and services buildings. Services buildings include commercial and institutional buildings, data centres, desalination plants and other non-specified buildings. Building energy use includes space heating and cooling, water heating, lighting, appliances and cooking equipment.

Bunkers: Include both international marine bunker fuels and international aviation bunker fuels.

Capacity credit: The proportion of the nameplate generating capacity of an electrical generator that can be reliably expected to generate electricity during times of peak demand on the grid to which it is connected. The sum of all capacity credits across an electricity system is useful as an approximation of the firm power that the system can reliably provide at a given time.

Carbon capture, utilisation and storage (CCUS)**:** The process of capturing carbon dioxide emissions from fuel combustion, industrial processes or directly from the atmosphere. Captured CO_2 emissions can be stored in underground geological formations, onshore or offshore, or used as an input or feedstock in manufacturing.

Carbon dioxide (CO_2)**:** A gas consisting of one part carbon and two parts oxygen. It is an important greenhouse (heat-trapping) gas.

Chemical feedstock: Physical energy products used as raw materials to produce chemical products, typically in the chemical and petrochemical sector. Examples are oil-based ethane or naphtha to produce ethylene in steam crackers.

Clean cooking systems: Cooking solutions that release less harmful pollutants, are more efficient and environmentally sustainable than traditional cooking options that use solid biomass, coal or kerosene. It refers to advanced biomass cook stoves, biogas or biodigester systems, electric stoves, liquefied petroleum gas, natural gas or ethanol stoves.

Clean energy: In *power*, clean energy includes renewable energy sources; nuclear power; fossil fuels fitted with CCUS; hydrogen and ammonia; battery storage; and electricity grids. In *efficiency*, clean energy includes energy efficiency in buildings, industry and transport, excluding domestic navigation. In *end-use applications*, clean energy includes direct use of renewables; electric vehicles; electrification in buildings, industry and international marine transport; CCUS in industry; and direct air capture. In *fuel supply*, clean energy includes low-emissions fuels, direct air capture and measures to reduce the emissions intensity of fossil fuel production.

Coal: Consists of both primary coal, i.e. lignite, coking and steam coal, and derived fuels, e.g. patent fuel, brown-coal briquettes, coke-oven coke, gas coke, gas works gas, coke-oven gas, blast furnace gas and oxygen steel furnace gas. Peat is also included.

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Coalbed methane (CBM)**:** Category of unconventional natural gas that refers to methane found in coal seams.

Coal-to-gas (CTG)**:** A process by which mined coal is first turned into synthesis gas or syngas, i.e. a mixture of hydrogen and carbon monoxide, and then into synthetic methane.

Coal-to-liquids (CTL)**:** The transformation of coal into liquid hydrocarbons. This can be achieved either through coal gasification into synthesis gas or syngas, i.e. a mixture of hydrogen and carbon monoxide, combined with Fischer-Tropsch or methanol-to-gasoline synthesis to produce liquid fuels, or through the less developed direct coal liquefaction technologies in which coal is directly reacted with hydrogen.

Coking coal: A type of coal that can be used for steel making (as a chemical reductant and a source of heat), in which it produces coke capable of supporting a blast furnace charge. Coal of this quality is commonly known as metallurgical coal.

Concentrating solar power (CSP)**:** Thermal power generation technology that collects and concentrates sunlight to produce high-temperature heat to generate electricity.

Conventional natural gas: Refers to natural gas extracted using traditional drilling techniques. It includes both onshore and offshore natural gas, including from the Arctic.

Conventional oil: Refers to oil extracted using traditional drilling methods. It includes onshore and offshore crude oil, including from the Arctic, enhanced oil recovery and natural gas liquids produced from conventional gas fields.

Cooling degree days: A measure of cooling needs. It quantifies the difference between a reference temperature (21 °C) and daily mean outdoor temperatures on days when the latter exceed the reference temperature, summed over the year. Regional values are population-weighted to reflect the spatial distribution of the population.

Critical minerals: A wide range of minerals and metals that are essential for key energy, digital and other modern technologies, but whose supply chains are vulnerable to disruption. While definitions and criteria vary across countries, they typically include chromium, cobalt, copper, gallium, germanium, graphite, lithium, manganese, molybdenum, nickel, platinum group metals, zinc and rare earth elements.

Data centres: Facilities that house information technology (IT) equipment, such as servers, storage systems and networking equipment, and are equipped with cooling and other auxiliary systems to keep the IT equipment operating under optimal conditions.

Decomposition analysis: A statistical method that decomposes an aggregate indicator to quantify the relative contribution of a set of pre-defined factors leading to a change in the aggregate indicator. The *World Energy Outlook* uses an additive index decomposition of the type Logarithmic Mean Divisia Index (LMDI).

Demand-side integration (DSI)**:** Consists of two types of measures: actions that influence load shape, such as energy efficiency and electrification; and actions that manage load, such as demand-side response measures.

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Demand-side response (DSR)**:** Describes actions which can influence the load profile, such as shifting the load curve in time without affecting total electricity demand, or load shedding, such as interrupting demand for a short duration or adjusting the intensity of demand for a certain amount of time.

Direct air capture (DAC)**:** A type of CCUS technology that captures CO_2 directly from the atmosphere using liquid solvents or solid sorbents. It is generally coupled with permanent storage of the CO_2 in deep geological formations or its use in the production of fuels, chemicals, building materials or other products. When coupled with permanent geological CO_2 storage, DAC is a carbon removal technology, and it is known as direct air capture and storage (DACS).

Dispatchable generation: Electricity from technologies whose power output can be readily controlled up to the nameplate capacity, i.e. increased to maximum rated capacity or decreased to zero, in order to help match supply with demand.

Electric arc furnace: Furnace that heats material by means of an electric arc. It is used for scrap-based steel production but also for ferroalloys, aluminium, phosphorus or calcium carbide.

Electric vehicles (EVs)**:** Electric vehicles include battery electric vehicles (BEVs) and plug-in hybrid electric vehicles (PHEVs).

Electricity demand: Defined as total gross electricity generation less own use generation, plus net trade (imports less exports), less transmission and distribution losses.

Electricity generation: Defined as the total amount of electricity generated by power-only or combined heat and power plants, including generation required for own use. This is also referred to as gross generation.

Electrolysis: Process of converting electric energy to chemical energy. Most relevant for the energy sector is water electrolysis, which splits water molecules into hydrogen and oxygen molecules. The resulting hydrogen is called electrolytic hydrogen.

End-use sectors: Include industry, transport, buildings and other, i.e. agriculture and other non-energy use.

Energy demand: See 'total energy supply'.

Energy-intensive industries: Includes production and manufacturing in the branches of iron and steel, chemicals, non-metallic minerals (including cement), non-ferrous metals (including aluminium), and paper, pulp and printing.

Energy-related and industrial process CO_2 emissions: Carbon dioxide emissions from fuel combustion, industrial processes, and fugitive and flaring CO_2 from fossil fuel extraction. Unless otherwise stated, CO_2 emissions in the *World Energy Outlook* refer to energy-related and industrial process CO_2 emissions.

Energy sector greenhouse gas (GHG) **emissions:** Includes CO_2 emissions from fossil fuel and non-renewable waste combustion, fugitive CO_2 emissions, and vented methane (CH_4) and

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nitrous dioxide (N_2O) emissions from the energy sector. CO_2 emissions from industrial processes are excluded.

Energy services: A personal or societal gain from the use of energy. Includes, inter alia, heating, cooling, lighting, entertainment, mobility, nourishment, hygiene and education. These services are delivered in different ways that cannot be compared directly, and useful energy provides a standardised framework to quantify these services in an energy-based measure.

Ethanol: An alcohol with broad application in the chemical sector and as a fuel additive. When produced from bioresources, it is known as bioethanol, which has applications as biogasoline, a liquid fuel, and as a biochemical. In the *World Energy Outlook*, the term exclusively refers to bioethanol.

Fischer-Tropsch synthesis: Catalytic process to produce synthetic fuels, e.g. diesel, kerosene or naphtha, typically from mixtures of carbon monoxide and hydrogen (synthesis gas or syngas). The inputs to Fischer-Tropsch synthesis can be from biomass, coal, natural gas, or hydrogen and CO_2.

Fossil fuels: Coal, oil and natural gas. Total fossil fuel use is equal to unabated fossil fuels plus fossil fuels with CCUS and non-energy use of fossil fuels.

Gaseous fuels: Fuels in gaseous form, including natural gas, biogas, biomethane, hydrogen and synthetic methane.

Gases: See 'gaseous fuels'.

Gas-to-liquids (GTL)**:** A process by which methane reacts with oxygen or steam to produce synthesis gas or syngas, i.e. a mixture of hydrogen and carbon monoxide, followed by Fischer-Tropsch synthesis. This is similar to the process used in coal-to-liquids.

Geothermal: Heat derived from the sub-surface of the earth, usually using a working fluid such as water and/or steam to bring the energy to the surface. Depending on its characteristics, geothermal energy can be used for heating and cooling or be harnessed to generate clean electricity if the temperature is adequate.

Heat (end-use)**:** Can be obtained from the combustion of fossil or renewable fuels, direct geothermal or solar heat systems, exothermic chemical processes and electricity (through resistance heating or heat pumps, which can extract heat from ambient air and liquids). This category refers to the wide range of end-uses, including space and water heating, cooking in buildings, and desalination and process applications in industry. It does not include cooling applications.

Heat (supply)**:** Obtained from the combustion of fuels, nuclear reactors, large-scale heat pumps, geothermal or solar resources. It may be used for heating or cooling, or converted into mechanical energy for transport or electricity generation. Commercial heat sold is reported under total final consumption with the fuel inputs allocated under power generation.

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Heating degree days: A measure of heating needs. It quantifies the difference between a reference temperature (16 °C) and daily mean outdoor temperatures on days when the latter fall below the reference temperature, summed over the year. Regional values are population-weighted to reflect the spatial distribution of the population.

Heavy-duty trucks (HDTs): Include both medium freight trucks (gross weight 3.5-15 tonnes) and heavy freight trucks (gross weight >15 tonnes).

Heavy-duty vehicles (HDVs): Include medium freight trucks (gross weight 3.5 to 15 tonnes), heavy freight trucks (gross weight >15 tonnes) and buses.

Heavy industries: Iron and steel, chemicals and cement.

Hydrogen: Hydrogen is used in the energy system as an energy carrier or as an industrial raw material, or is combined with other inputs to produce hydrogen-based fuels. Unless otherwise stated, hydrogen in this report refers to low-emissions hydrogen.

Hydrogen-based fuels: Include ammonia and synthetic hydrocarbons (gases and liquids) that derive their energy content from a pure, or nearly pure, hydrogen feedstock. If produced from low-emissions hydrogen, these fuels are low-emissions hydrogen-based fuels.

Hydropower: Refers to the electricity produced in hydropower projects. It excludes output from pumped storage and marine technologies (e.g. tidal and wave).

Improved cook stoves: Intermediate and advanced improved biomass cook stoves (ISO tier ≥3). It excludes basic cookstoves (ISO tier 0-2).

Industry: The sector includes fuel used within the manufacturing and construction industries. Key industry branches include iron and steel, chemicals and petrochemicals, cement, aluminium, and pulp and paper. Use by industries for the transformation of energy into another form or for the production of fuels is excluded and reported separately under other energy sector. There is an exception for fuel transformation in blast furnaces and coke ovens, which are reported within iron and steel. Consumption of fuels for the transport of goods is reported as part of the transport sector, while consumption of fuels by off-road vehicles is reported under the specific sector. For instance, fuels consumed by bulldozers as a part of industrial operations is reported in industry.

International aviation bunkers: Include the deliveries of aviation fuels to aircraft for international aviation. Fuels used by airlines for their road vehicles are excluded. The domestic-international split is determined on the basis of departure and landing locations and not by the nationality of the airline. For many countries, this incorrectly excludes fuels used by domestically owned carriers for their international departures.

International marine bunkers: Include the quantities delivered to ships of all flags that are engaged in international navigation. The international navigation may take place at sea, on inland lakes and waterways, and in coastal waters. Consumption by ships engaged in domestic navigation is excluded. The domestic-international split is determined on the basis of port of departure and port of arrival, and not by the flag or nationality of the ship.

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Consumption by fishing vessels and by military forces is excluded and instead included in the residential, services and agriculture category.

Investment: Investment is the capital expenditure in energy supply, infrastructure, end-use and efficiency. Fuel supply investment includes the production, transformation and transport of oil, gas, coal and low-emissions fuels. *Power sector* investment includes new construction and refurbishment of generation, electricity grids (transmission, distribution and public electric vehicle chargers), and battery storage. *Energy efficiency* investment includes efficiency improvements in buildings, industry and transport. *Other end-use* investment includes the purchase of equipment for the direct use of renewables, electric vehicles, electrification in buildings, industry and international marine transport, equipment for the use of low-emissions fuels, and CCUS in industry and direct air capture. Data and projections reflect spending over the lifetime of projects and are presented in real terms in year-2025 US dollars converted at market exchange rates unless otherwise stated. Total investment reported for a year reflects the amount spent in that year.

Levelised cost of electricity (LCOE)**:** An indicator of the expected average production cost for each unit of electricity generated by a technology over its economic lifetime. The LCOE combines into a single metric all the cost elements directly associated with a given power technology, including construction, financing, fuel, maintenance and costs associated with a carbon price. It does not include network integration or other indirect costs. For a more complete indicator, see 'value-adjusted levelised cost of electricity (VALCOE)'.

Light-duty vehicles (LDVs)**:** Include passenger cars and light commercial vehicles (gross vehicle weight < 3.5 tonnes).

Light industries: Include non-energy-intensive industries: food and tobacco; machinery; mining and quarrying; transport equipment; textiles; wood harvesting and processing; and construction.

Lignite: A type of coal that is used in the power sector mostly in regions near lignite mines due to its low energy content and typically high moisture levels, which generally make long-distance transport uneconomic. In the *World Energy Outlook,* data on lignite include peat.

Liquid biofuels: Liquid fuels derived from biomass or waste feedstock, including ethanol, biodiesel and biojet fuels. Unless otherwise stated, biofuels are expressed in energy-equivalent volumes of gasoline, diesel and kerosene.

Liquid fuels: Include oil, liquid biofuels, synthetic oil products and hydrogen-based fuels, i.e. ammonia and methanol.

Low-emissions electricity: Includes output from renewable energy technologies, nuclear power, fossil fuels fitted with CCUS, hydrogen and ammonia.

Low-emissions fuels: Include modern bioenergy, low-emissions hydrogen and low-emissions hydrogen-based fuels.

Low-emissions gases: Include biogas, biomethane, low-emissions hydrogen and low-emissions synthetic methane.

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Low-emissions hydrogen: Includes hydrogen that is produced through water electrolysis with electricity generated from a low-emissions source, e.g. solar, wind and nuclear power. Hydrogen produced from biomass or from fossil fuels with CCUS technology is also counted as low-emissions hydrogen. Production from fossil fuels with CCUS is included only if upstream emissions are sufficiently low, if capture at high rates is applied to all CO_2 streams associated with the production route, and if all CO_2 is permanently stored to prevent its release into the atmosphere. The same principle applies to low-emissions feedstocks and hydrogen-based fuels made using low-emissions hydrogen and a sustainable carbon source of biogenic origin or directly captured from the atmosphere.

Low-emissions hydrogen-based fuels: Fuels produced from low-emissions hydrogen. Include ammonia, methanol and other synthetic hydrocarbons (gases and liquids) made from low-emissions hydrogen when any carbon inputs, e.g. from CO_2, are not from fossil fuels or fossil-derived process emissions.

Low-emissions hydrogen-based liquid fuels: A subset of low-emissions hydrogen-based fuels that includes only ammonia, methanol and synthetic liquid hydrocarbons, such as synthetic kerosene.

Lower heating value: Heat liberated by the complete combustion of a unit of fuel when the water produced is assumed to remain as a vapour and the heat is not recovered.

Marine energy: Mechanical energy harvested from ocean currents, tidal movement or wave motion and exploited for electricity generation.

Middle distillates: Include jet fuel, diesel and heating oil.

Mini-grids: Small electric grid systems, not connected to main electricity networks, linking a number of households and/or other consumers.

Modern energy access: Includes household access to a minimum level of electricity, initially equivalent to 250 kilowatt-hours (kWh) annual demand for a rural household and 500 kWh for an urban household; household access to less harmful and more sustainable cooking and heating fuels, and improved/advanced stoves; access that enables productive economic activity; and access for public services.

Modern gaseous bioenergy: See 'biogases'.

Modern liquid bioenergy: Includes biogasoline, biodiesel, biojet kerosene and other liquid biofuels.

Modern renewables: Include all renewables except the traditional use of solid biomass.

Modern solid bioenergy: Includes all solid bioenergy products except the traditional use of biomass. It also includes the use of solid bioenergy in intermediate and advanced improved biomass cook stoves (ISO tier > 1), requiring fuel to be cut into small pieces or often using processed biomass such as pellets.

Natural gas: A gaseous fossil fuel, consisting mostly of methane. Occurs in deposits, whether liquefied or gaseous. In IEA analysis and statistics, it includes both non-associated gas

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originating from fields producing hydrocarbons only in gaseous form, and associated gas produced in association with crude oil production, as well as methane recovered from coal mines. Natural gas liquids, manufactured gas (i.e. produced from municipal or industrial waste, or sewage) and quantities vented or flared are not included. Natural gas data in cubic metres are expressed on a gross calorific value basis and are measured at 15 °C and at 760 mm Hg (Standard Conditions). Natural gas data expressed in tonnes of oil equivalent, mainly to allow comparison with other fuels, are on a net calorific basis. The difference between the net and the gross calorific value is the latent heat of vaporisation of the water vapour produced during combustion of the fuel.

Natural gas liquids (NGLs)**:** Liquid or liquefied hydrocarbons produced in the manufacture, purification and stabilisation of natural gas. NGLs are portions of natural gas recovered as liquids in separators, field facilities or gas processing plants. NGLs include, but are not limited to, ethane (when it is removed from the natural gas stream), propane, butane, pentane, natural gasoline and condensates.

Network gases: Gaseous fuels transported in a pipeline gas network, either separately or blended together. Include natural gas, biomethane, synthetic methane and hydrogen blended in a gas network.

Non-energy-intensive industries: See 'other industry'.

Non-energy use: The use of energy products as raw materials for the manufacture of non-energy products, e.g. natural gas used to produce fertiliser, as well as for direct uses that do not involve using the products as a source of energy or as a transformation input, e.g. lubrication, sealing, road surfacing, preservation or use as a solvent. For biofuels, only the amounts specifically used for energy purposes, a small part of the total, are included in energy statistics. Therefore, the non-energy use of biomass is not taken into consideration and the quantities are null by definition.

Non-renewable waste: Non-biogenic waste, such as plastics in municipal or industrial waste.

Nuclear power: Refers to the electricity produced by a nuclear reactor, assuming an average conversion efficiency of 33%.

Off-grid systems: Mini-grids and stand-alone systems for individual households or groups of consumers not connected to a main grid.

Offshore wind: Refers to electricity produced by wind turbines that are installed in open water, usually in the ocean. Includes fixed offshore wind (fixed to the seabed) and floating offshore wind.

Oil: A liquid fuel. Usually refers to fossil fuel mineral oil. Includes oil from both conventional and unconventional oil production. Petroleum products include refinery gas, ethane, liquefied petroleum gas (LPG), aviation gasoline, motor gasoline, jet fuel, kerosene, gas/diesel oil, heavy fuel oil, naphtha, white spirits, lubricants, bitumen, paraffin waxes and petroleum coke.

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Other energy sector: Covers the use of energy by transformation industries and energy losses in converting primary energy into a form that can be used in the final consuming sectors. It includes losses in low-emissions hydrogen and hydrogen-based fuels production, bioenergy processing, gas works, petroleum refineries, coal and gas transformation and liquefaction. It also includes energy own use in coal mines, in oil and gas extraction and in electricity and heat production. Transfers and statistical differences are also included in this category. Fuel transformation in blast furnaces and coke ovens is not accounted for in the other energy sector category.

Other industry: A category of industry branches that includes construction, food processing, machinery, mining, textiles, transport equipment, wood processing and remaining industry. It is sometimes referred to as non-energy-intensive industry.

Passenger car: A road motor vehicle, other than a moped or a motorcycle, intended to transport passengers. It includes vans designed and used primarily to transport passengers. Excluded are light commercial vehicles, motor coaches, urban buses and mini-buses/mini-coaches.

Peat: A solid formed from the partial decomposition of dead vegetation under conditions of high humidity and limited air access, i.e. the initial stage of coalification. It is available in two forms for use as a fuel, sod peat and milled peat. Peat used for non-energy purposes is not included.

Petrochemicals: A subset of industrial chemicals, which includes chemicals derived from petroleum (oil) products, such as ethane and naphtha, or from natural gas. The petrochemical sector covers ethylene, propylene, aromatics (benzene, toluene, mixed aromatics), plastics, synthetic fibres, rubber, ammonia and methanol. The petrochemicals listed above can all technically be produced today from a variety of products and substances, including biomass, hydrogen and CO_2. However, the vast majority of industrial chemicals use oil, natural gas or coal both as their input materials and as the sources of energy for fuelling the production processes.

Plastic collection rate: Proportion of plastic that is collected for recycling relative to the quantity of recyclable waste available.

Plastic waste: Refers to all post-consumer plastic waste with a lifespan of more than one year.

Power generation: Refers to electricity generation and heat production from all sources of electricity, including electricity-only power plants, heat plants and co-generation, i.e. combined heat and power plants. Both main activity producer plants and small plants that produce fuel for their own use, i.e. auto-producers, are included.

Primary chemicals: Include ethylene, propylene, benzene, toluene, mixed xylenes, ammonia and methanol.

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Process emissions: CO_2 emissions produced from industrial processes which chemically or physically transform materials. A notable example is cement production, in which CO_2 is emitted when calcium carbonate is transformed into lime, which in turn is used to produce clinker.

Process heat: The use of thermal energy to produce, treat or alter manufactured goods.

Productive uses: Energy used towards an economic purpose: agriculture, industry, services and non-energy use. Some energy demand from the transport sector, for example freight, could be considered as productive, but it is treated separately.

Rare earth elements (REEs)**:** A group of 17 chemical elements in the periodic table, specifically the 15 lanthanides plus scandium and yttrium. REEs are vital inputs for key energy technologies, including wind turbines, electric vehicle motors and electrolysers.

Renewables: Include bioenergy, geothermal, hydropower, solar photovoltaics, concentrating solar power, wind and marine (tidal and wave) energy for electricity and heat generation. Excludes traditional use of biomass.

Residential: Energy used by households, including space heating and cooling, water heating, lighting, appliances, electronic devices and cooking.

Road transport: This refers to all road vehicle types, i.e. passenger cars, two/three-wheelers, light commercial vehicles, buses and medium freight and heavy freight trucks.

Self-sufficiency: Corresponds to indigenous production divided by total energy supply.

Services: A component of the buildings sector. It represents energy used in commercial facilities, e.g. offices, shops, hotels, restaurants, and in institutional buildings such as schools, hospitals and public offices. Energy use in services includes space heating and cooling, water heating, lighting, appliances, cooking, data centres and desalination.

Shale gas: A type of unconventional natural gas contained within a commonly occurring rock classified as shale. Shale formations are characterised by low permeability, with more limited ability for gas to flow through the rock than within a conventional reservoir. Shale gas is generally produced using hydraulic fracturing. See also 'tight oil'.

Shipping/navigation: This transport mode includes both domestic and international navigation and their use of marine fuels. Domestic navigation covers the transport of goods or people on inland waterways and for national sea voyages (starting and ending in the same country without any intermediate foreign port). International navigation includes quantities of fuels delivered to merchant ships, including passenger ships, of any nationality for consumption during international voyages transporting goods or passengers.

Single-use plastics (or disposable plastics)**:** Plastic items used only one time before disposal.

Solar: Includes solar photovoltaics (PV), concentrating solar power (CSP), and solar heating and cooling.

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Solar home systems (SHS)**:** Small-scale photovoltaic and battery stand-alone systems, i.e. with capacity higher than or equal to 10 watt peak (Wp) supplying electricity for single households or small businesses. They are most often used off-grid, but also where grid supply is not reliable. Although all SHS are included in the IEA access to electricity definition and historical counting, only solar home systems from 25 Wp in rural areas and 50 Wp in urban areas are deployed in the IEA scenarios for population gaining access. It excludes solar systems smaller than 10 Wp, i.e. multi-light systems and solar lanterns.

Solar photovoltaics (PV)**:** Electricity produced from solar photovoltaic cells, including utility-scale and small-scale installations.

Solid bioenergy: Includes charcoal, fuelwood, dung, agricultural residues, wood waste and other solid biogenic wastes.

Solid fuels: Include coal, modern solid bioenergy, traditional use of biomass, and industrial and municipal wastes.

Stand-alone systems: Small-scale autonomous electricity supply for households or small businesses. They are generally used off-grid, but also where grid supply is not reliable. Stand-alone systems include solar home systems, small wind or hydro generators and diesel or gasoline generators. The difference compared with mini-grids is in scale and in that stand-alone systems do not have a distribution network serving multiple customers.

Steam coal: A type of coal that is mainly used for heat production or steam-raising in power plants and, to a lesser extent, in industry. Typically, steam coal is not of sufficient quality for steel making. Coal of this quality is also commonly known as thermal coal.

Synthetic methane: Methane from sources other than natural gas, including coal-to-gas and low-emissions synthetic methane.

Synthetic oil: Liquid fuels obtained via a process other than the refining of crude oil or bituminous oils. Synthetic oil is produced through Fischer-Tropsch conversion or methanol synthesis. It includes oil products from coal-to-liquids, gas-to-liquids and non-ammonia low-emissions hydrogen-based liquid fuels.

Temperature overshoot: Temporary exceedance of a specified level of global warming, such as 1.5 °C. Overshoot implies a peak followed by a decline in global warming, achieved through anthropogenic removal of CO_2 exceeding remaining CO_2 emissions globally.

Tight oil: A type of unconventional oil produced from shale or other very low-permeability formations, generally using hydraulic fracturing. Sometimes referred to as light tight oil. Tight oil includes tight crude oil and condensate production except for the United States, which includes tight crude oil only. (US tight condensate volumes are included in natural gas liquids).

Total energy supply (TES)**:** Represents domestic demand only and is equivalent to electricity and heat generation plus the other energy sector, excluding electricity, heat and hydrogen,

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plus total final consumption, excluding electricity, heat and hydrogen. TES does not include ambient heat from heat pumps or electricity trade.

Total final consumption (TFC)**:** Is the sum of consumption by the various end-use sectors. TFC is broken down into energy demand in the following sectors: industry (including manufacturing, mining, chemicals production, blast furnaces and coke ovens); transport; buildings (including residential and services); and other (including agriculture and other non-energy use). It excludes international marine and aviation bunkers, except at world level where it is included in the transport sector.

Total final energy consumption (TFEC)**:** It incorporates total final consumption by end-use sectors, but it excludes non-energy use. It excludes international marine and aviation bunkers, except at world level. Typically, this is used to calculate the electrification rate (share of electricity consumption in total final energy consumption) or the renewable energy share in total final energy consumption for indicator 7.2.1 of the United Nations Sustainable Development Goals.

Traditional use of biomass: Refers to the use of solid biomass with basic technologies, such as a three-stone fire or basic improved cook stove (ISO tier 0-2), often with no or poorly operating chimneys. Forms of biomass used include wood, wood waste, charcoal, agricultural residues and other bio-sourced fuels such as animal dung.

Transport: Includes fuels and electricity used in the transport of goods or people within the national territory, irrespective of the economic sector within which the activity occurs. This includes fuel and electricity delivered to vehicles using public roads or for use in rail vehicles; fuel delivered to vessels for domestic navigation; fuel delivered to aircraft for domestic aviation; and energy consumed in the delivery of fuels through pipelines. Energy consumption from marine and aviation bunkers is presented only at the world level and is excluded from the transport sector at a domestic level.

Trucks: Includes all size categories of commercial vehicles: light trucks (gross vehicle weight < 3.5 tonnes); medium freight trucks (gross vehicle weight 3.5-15 tonnes); and heavy freight trucks (gross vehicle weight > 15 tonnes).

Unabated fossil fuel use: Fossil fuels used for energy purposes without carbon capture, utilisation and storage (CCUS). Total fossil fuel use is equal to unabated fossil fuels plus fossil fuels with CCUS plus non-energy use of fossil fuels.

Unconventional natural gas: Includes tight gas, shale gas, coalbed methane, gas hydrates and coal-to-gas products.

Unconventional oil: Includes mining and in-situ extra-heavy oil and bitumen, synthetic crudes made by upgrading bituminous (e.g. oil sands in Canada) or extra-heavy crude oils, light tight oil, kerogen oil, coal-to-liquids (CTL) and gas-to-liquids (GTL) products, additives and natural gas liquids from unconventional natural gas fields.

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Useful energy: Useful energy is the portion of energy in a system that performs the intended task. In other words, useful energy is the part of the input energy that is converted into the desired output form, accounting for end-use conversion efficiencies. For example, in transport, this is the energy that moves the vehicle and enables the provision of mobility services; in buildings lighting, this is the light produced by the light bulb; or in industry steel making factories, the chemical and thermal energy required to reduce iron ore into liquid iron metal. Useful energy measures energy services provided by modern energy sources; it does not include non-energy use or traditional use of biomass, while they both are reported at the final consumption level.

Value-adjusted levelised cost of electricity (VALCOE)**:** A more complete metric to evaluate the competitiveness of power generation technologies, which includes all direct technology costs (LCOE) combined with the estimated value of three services provided to the system: energy, flexibility and capacity.

Variable renewable energy (VRE)**:** Sources of renewable energy, usually electricity, for which the maximum output of an installation at a given time depends on the availability of fluctuating environmental inputs. VRE includes a broad array of technologies such as wind power, solar PV, run-of-river hydro, concentrating solar power where no thermal storage is included, and marine energy (tidal and wave).

Zero-carbon building (ZCB)**:** A building where both the thermal envelope and technical building systems are highly energy efficient, which uses either renewable energy directly or an energy supply that can be fully decarbonised, such as electricity or district heat.

Zero-carbon-ready building (ZCRB)**:** A building where both the thermal envelope and technical building systems are highly energy efficient. Orientation and glazing are optimised, and all the essential passive elements of the thermal envelope are highly energy efficient to manage heat transfer and solar gains, ensuring the necessary comfort of occupants in all seasons. In major heating markets, when hydronic systems are used, the heating distribution system is prepared for low-temperature heat flow. In major cooling markets, zero-carbon-ready buildings are designed to optimise natural ventilation and make use of shading and reflective or green roofs to minimise heat gains. Heating and cooling service demand of new zero-carbon-ready buildings is below 40 kWh/m2/year, except for high-latitude regions and tropical regions with exceedingly high levels of humidity. Existing buildings can reach such a level of performance if retrofitted to ensure that technical building systems and all the essential passive elements of the thermal envelope are highly energy efficient, that shading and reflective or green roofs are used to minimise heat gains, and that the heating distribution system is prepared for low-temperature heat flow.

Zero emissions vehicles (ZEVs)**:** Vehicles that can operate without tailpipe CO_2 emissions, i.e. battery electric, plug-in hybrid and fuel cell vehicles.

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Regional and country groupings

Advanced economies: Organisation for Economic Co-operation and Development (OECD) regional grouping and Bulgaria, Croatia, Cyprus[1,2], Malta and Romania.

Africa: North Africa and sub-Saharan Africa regional groupings.

Asia Pacific: Southeast Asia regional grouping and Australia, Bangladesh, Democratic People's Republic of Korea (North Korea), India, Japan, Korea, Mongolia, Nepal, New Zealand, Pakistan, The People's Republic of China (China), Sri Lanka, Chinese Taipei and other Asia Pacific countries and territories.[3]

Caspian: Armenia, Azerbaijan, Georgia, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan.

Central and South America: Argentina, Plurinational State of Bolivia (Bolivia), Bolivarian Republic of Venezuela (Venezuela), Brazil, Chile, Colombia, Costa Rica, Cuba, Curaçao, Dominican Republic, Ecuador, El Salvador, Guatemala, Guyana, Haiti, Honduras, Jamaica, Nicaragua, Panama, Paraguay, Peru, Suriname, Trinidad and Tobago, Uruguay and other Central and South American countries and territories.[4]

China: Includes (The People's Republic of) China and Hong Kong, China.

Developing Asia: Asia Pacific regional grouping excluding Australia, Japan, Korea and New Zealand.

Emerging market and developing economies: All other countries not included in the advanced economies regional grouping.

Eurasia: Caspian regional grouping and the Russian Federation (Russia).

Europe: European Union regional grouping and Albania, Belarus, Bosnia and Herzegovina, Gibraltar, Iceland, Israel[5], Kosovo, Montenegro, North Macedonia, Norway, Republic of Moldova, Serbia, Switzerland, Türkiye, Ukraine and United Kingdom.

European Union: Austria, Belgium, Bulgaria, Croatia, Cyprus[1,2], Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, the Netherlands, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain and Sweden.

IEA (International Energy Agency)**:** Australia, Austria, Belgium, Canada, Czechia, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Japan, Korea, Latvia, Lithuania, Luxembourg, Mexico, New Zealand, Norway, Poland, Portugal, Slovak Republic, Spain, Sweden, Switzerland, the Netherlands, Türkiye, United Kingdom and United States.

Latin America and the Caribbean (LAC)**:** Central and South America regional grouping and Mexico.

Middle East: Bahrain, Islamic Republic of Iran (Iran), Iraq, Jordan, Kuwait, Lebanon, Oman, Qatar, Saudi Arabia, Syrian Arab Republic (Syria), United Arab Emirates and Yemen.

Non-OECD: All other countries not included in the OECD regional grouping.

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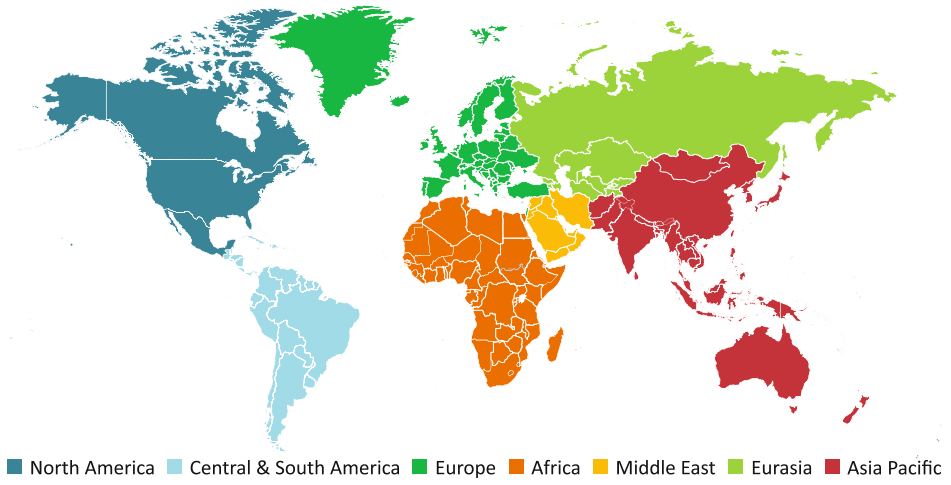
Figure C.1 ▷ Main country groupings



Note: This map is without prejudice to the status of or sovereignty over any territory, to the delimitation of international frontiers and boundaries and to the name of any territory, city or area.

Non-OPEC: All other countries not included in the OPEC regional grouping.

North Africa: Algeria, Egypt, Libya, Morocco and Tunisia.

North America: Canada, Mexico and United States.

OECD (Organisation for Economic Co-operation and Development)**:** IEA grouping plus Chile, Colombia, Costa Rica, Iceland, Israel and Slovenia.

OPEC (Organization of the Petroleum Exporting Countries)**:** Algeria, Bolivarian Republic of Venezuela (Venezuela), Equatorial Guinea, Gabon, Iraq, Islamic Republic of Iran (Iran), Kuwait, Libya, Nigeria, Republic of the Congo (Congo) and Saudi Arabia.

OPEC+: OPEC grouping plus Azerbaijan, Bahrain, Brunei Darussalam, Kazakhstan, Malaysia, Mexico, Oman, Russian Federation, South Sudan and Sudan.

Southeast Asia: Brunei Darussalam, Cambodia, Indonesia, Lao People's Democratic Republic (Lao PDR), Malaysia, Myanmar, Philippines, Singapore, Thailand and Viet Nam. These countries are all members of the Association of Southeast Asian Nations (ASEAN). Timor-Leste joined ASEAN on 26 October 2025 and is not included in this grouping in this publication.

Sub-Saharan Africa: Angola, Benin, Botswana, Cameroon, Côte d'Ivoire, Democratic Republic of the Congo (DRC), Equatorial Guinea, Eritrea, Ethiopia, Gabon, Ghana, Kenya, Kingdom of Eswatini, Madagascar, Mauritius, Mozambique, Namibia, Niger, Nigeria, Republic of the Congo (Congo), Rwanda, Senegal, South Africa, South Sudan, Sudan, United Republic of Tanzania (Tanzania), Togo, Uganda, Zambia, Zimbabwe and other African countries and territories.[6]

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Country notes

[1] Note by Republic of Türkiye: The information in this document with reference to "Cyprus" relates to the southern part of the island. There is no single authority representing both Turkish and Greek Cypriot people on the island. Türkiye recognises the Turkish Republic of Northern Cyprus (TRNC). Until a lasting and equitable solution is found within the context of the United Nations, Türkiye shall preserve its position concerning the "Cyprus issue".

[2] Note by all the European Union Member States of the OECD and the European Union: The Republic of Cyprus is recognised by all members of the United Nations with the exception of Türkiye. The information in this document relates to the area under the effective control of the Government of the Republic of Cyprus.

[3] Individual data are not available and are estimated in aggregate for: Afghanistan, Bhutan, Cook Islands, Fiji, French Polynesia, Kiribati, Macau (China), Maldives, New Caledonia, Palau, Papua New Guinea, Samoa, Solomon Islands, Timor-Leste, Tonga and Vanuatu.

[4] Individual data are not available and are estimated in aggregate for: Anguilla, Antigua and Barbuda, Aruba, Bahamas, Barbados, Belize, Bermuda, Bonaire, Sint Eustatius and Saba, British Virgin Islands, Cayman Islands, Dominica, Falkland Islands (Malvinas), Grenada, Montserrat, Saint Kitts and Nevis, Saint Lucia, Saint Pierre and Miquelon, Saint Vincent and Grenadines, Saint Maarten (Dutch part) and Turks and Caicos Islands.

[5] The statistical data for Israel are supplied by and under the responsibility of the relevant Israeli authorities. The use of such data by the OECD and/or the IEA is without prejudice to the status of the Golan Heights, East Jerusalem and Israeli settlements in the West Bank under the terms of international law.

[6] Individual data are not available and are estimated in aggregate for: Burkina Faso, Burundi, Cabo Verde, Central African Republic, Chad, Comoros, Djibouti, Gambia, Guinea, Guinea-Bissau, Lesotho, Liberia, Malawi, Mali, Mauritania, Sao Tome and Principe, Seychelles, Sierra Leone and Somalia.

Abbreviations and acronyms

AC	air conditioner (buildings)
AC	alternating current (electricity)
ACCESS	Accelerating Clean Cooking and Electricity Services Scenario
AFOLU	agriculture, forestry and other land use
AI	artificial intelligence
APEC	Asia-Pacific Economic Cooperation
ARC	Additional Response Case
ASEAN	Association of Southeast Asian Nations
BECCS	bioenergy equipped with CCUS
BEV	battery electric vehicle
BTM	behind the meter
CAAGR	compound average annual growth rate
CAFE	corporate average fuel economy standards
CBM	coalbed methane
CCGT	combined-cycle gas turbine
CCUS	carbon capture, utilisation and storage
CDR	carbon dioxide removal
CEM	Clean Energy Ministerial
CH_4	methane
CHP	combined heat and power; the term co-generation is sometimes used
CNG	compressed natural gas

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CO	carbon monoxide
CO_2	carbon dioxide
CO_2-eq	carbon-dioxide equivalent
COP	Conference of the Parties (UNFCCC)
CPS	Current Policies Scenario
CSP	concentrating solar power
CTG	coal-to-gas
CTL	coal-to-liquids
DAC	direct air capture
DACS	direct air capture and storage
DC	direct current
DER	distributed energy resources
DFI	development finance institutions
DRI	direct reduced iron
DSI	demand-side integration
DSO	distribution system operator
DSR	demand-side response
EHOB	extra-heavy oil and bitumen
EMDE	emerging market and developing economies
EOR	enhanced oil recovery
EPA	Environmental Protection Agency (United States)
ETS	emissions trading system
EU	European Union
EU ETS	European Union Emissions Trading System
EV	electric vehicle
FAO	Food and Agriculture Organization of the United Nations
FDI	foreign direct investment
FID	final investment decision
FiT	feed-in tariff
FOB	free on board
GDP	gross domestic product
GEC	Global Energy and Climate (IEA model)
GHG	greenhouse gases
GST	Global Stocktake
GTL	gas-to-liquids
GWP	global warming potential
H_2	hydrogen
HDV	heavy-duty vehicle
HEFA	hydrogenated esters and fatty acids
HFC	hydrofluorocarbon
HFO	heavy fuel oil
HVDC	high-voltage direct current
IAEA	International Atomic Energy Agency
ICE	internal combustion engine

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IEA	International Energy Agency
IGCC	integrated gasification combined-cycle
IIASA	International Institute for Applied Systems Analysis
IMF	International Monetary Fund
IMO	International Maritime Organization
IOC	international oil company
IPCC	Intergovernmental Panel on Climate Change
IPT	independent power transmission
IT	information technology
LCOE	levelised cost of electricity
LCV	light commercial vehicle
LDV	light-duty vehicle
LED	light-emitting diode
LFP	lithium iron phosphate
LHC	Low Hormuz Case
LNG	liquefied natural gas
LPG	liquefied petroleum gas
LULUCF	land use, land-use change and forestry
MEPS	minimum energy performance standards
MER	market exchange rate
N_2O	nitrous oxide
NDC	Nationally Determined Contribution
NEA	Nuclear Energy Agency (an agency within the OECD)
NGLs	natural gas liquids
NGV	natural gas vehicle
NH_3	ammonia
NOC	national oil company
NO_X	nitrogen oxides
NPV	net present value
NZE	Net Zero Emissions by 2050 Scenario
OECD	Organisation for Economic Co-operation and Development
OPEC	Organization of the Petroleum Exporting Countries
PHEV	plug-in hybrid electric vehicle
PLDV	passenger light-duty vehicle
PM	particulate matter
$PM_{2.5}$	fine particulate matter
PPA	power purchase agreement
PPP	purchasing power parity
PV	photovoltaics
R&D	research and development
RD&D	research, development and demonstration
SAF	sustainable aviation fuel
SDG	Sustainable Development Goals (United Nations)

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SHS	solar home systems
SLCP	short-lived climate pollutant
SME	small and medium enterprises
SO_2	sulphur dioxide
STEPS	Stated Policies Scenario
T&D	transmission and distribution
TES	total energy supply
TFC	total final consumption
TFEC	total final energy consumption
TFP	total factor productivity
TPED	total primary energy demand
TSO	transmission system operator
UAE	United Arab Emirates
UN	United Nations
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNFCCC	United Nations Framework Convention on Climate Change
US	United States
USGS	United States Geological Survey
VALCOE	value-adjusted levelised cost of electricity
VRE	variable renewable energy
WACC	weighted average cost of capital
WEO	World Energy Outlook
WHO	World Health Organization
ZCB	zero-carbon building
ZCRB	zero-carbon-ready building
ZEV	zero emissions vehicle

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Inputs to the Global Energy and Climate Model

General note

This annex includes references of databases and publications used to provide input data to the International Energy Agency (IEA) Global Energy and Climate (GEC) Model. The IEA's own databases of energy and economic statistics provide much of the data used in the GEC Model. These include IEA statistics on energy supply, transformation, demand at detailed levels, carbon dioxide emissions from fuel combustion and energy efficiency indicators that form the bedrock of the *World Energy Outlook* modelling and analyses.

Supplemental data from a wide range of external sources are used to complement IEA data and provide additional detail. This list of databases and publications is comprehensive, but not exhaustive. The abbreviation n.d. is used for undated publications.

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